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**Fishery statistics and commercialization
of the mangrove crab,
Ucides cordatus (L.),
in Bragança – Pará - Brazil**

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requirements for the degree of
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Abstract

This research was part of the scientific MADAM project developed in collaboration between Brazil and Germany. The work focused on fishery statistics and commercialization of the mangrove crab, *Ucides cordatus*, from the mangrove areas in Bragança District, Pará, Brazil. The study area was situated in a continuous mangrove area spanning three districts of the Pará State coast: Tracuateua, Bragança and Augusto Correa. This 6.000 km² area extends between the northeastern coast of Pará State and the northwestern coast of the Maranhão State (480 km of real coastline). The total mangrove area available to crab fishermen was approximately 877 km² divided among: Bragança Peninsula 170 km², west zone 181 km² and east zone 526 km².

The main objective of this study was to determine the yearly volume of crab landings (data from January of 2003 to June of 2004) in Bragança District and to identify the channels of and mercantile agents in the crab commercialization. By choosing local communities with the highest landing volume for monitoring, approximately 80% of the total catch in Bragança District could be directly monitored. The communities or points chosen for monitoring were: Caratateua, Tamatateua, Treme and the Bragança-Ajuruteua road (Taici).

Results showed that in 2003-2004, there were 1195 crab fishermen in Bragança District. The crab fishermen moved by small boats, canoes and on foot into the mangrove area. The total volume of recorded crab landings in Bragança District was 1859 t in 2003 and 1039 t from January to June of 2004. Due to the impossibility of monitoring all landing points the catch data presented, represent only approximately 80% of the total catch landed in Bragança District. The highest fishing pressure was recorded on the Bragança Peninsula. The mean CPUE in this area was 150 crabs/ man-day, and the carapace widths at capture varied between 5.1 and 9.1 cm. For the study period, the average carapace width of crabs captured on the Bragança peninsula was 7.1 ± 0.5 cm. The best growth parameter combination achieved by ELEFAN I was $L_{\infty} = 8.58$ cm and $K = 0.20$ / year. The probability of capture for *U. cordatus* males calculated with FISAT showed that the size class represented in the actual catch lay between 6.8 and 7.3 cm. The cohort analysis gave estimates of total mortality rate (Z) for this size class varied between 0.40 and 0.80 per year, increasing with increasing size (carapace width, cm). The same tendency was observed for the fishing mortality rate (F), where estimates varied between 0.0 and 0.4 per year.

The commercialization analysis showed that the crabs captured and landed in the Bragança District entered the market via the crab fishermen (producers) in two forms: a) *in natura* – live crab and b) processed - pulp and chelae crabmeat. For live crabs, the most frequently used unit in the landings was the *cambada*. The commercialization chain's main mercantile agent was the wholesaler/retailer

and it ran through three different commercialization channels. The average monthly net income for a producer with a boss was R\$ 314.00 and the producer without a boss received R\$ 367.00. The total markup (MKT) during the commercialization of live crab raised the end prices by 32% to 67% on the Bragança market and by 58% to 150% on the Belém market. The live crabs that were landed and sold at diverse points in Bragança District, supplied not only the local market, but the state market as well.

The processed crab was sold by the kilogram (Kg) and most frequently sold directly to the fisherman's boss (PC). The mercantile agents in the chain were: the middleman, the wholesaler and the retailer. Four processed crabmeat commercialization channels were identified. The average monthly net income of a producer with a boss was R\$ 590.00 and R\$ 594.00 for a producer without a boss. The total markup (MKT) in the commercialization system of pulp and *chela* crabmeat showed that the price paid by the final consumer during the year of 2003 was always more than double the price at first commercialization. The processed crabmeat was commercialized predominantly in Belém.

It can be concluded that the crab fishery in Bragança District produces enough financial resources to not only allow the local families to subsist but to maintain a large money flow within the communities that is not easily apparent to the outsider. The Bragança Peninsula still presents a favorable situation for sustainable exploitation because the average size of captured individuals is sufficiently higher than the size at first sexual maturation ($L_{50\%}=3.51$ cm for males and $L_{50\%}= 4.01$ for females). Though the exploitation is presently at sustainable levels, any small fishing effort increase, deforestation or the use of unlawful capture methods could rapidly lead to overfishing of large individuals.

Resumo

Este trabalho foi parte do projeto de cooperação científica MADAM desenvolvido entre o Brasil-Alemanha. O estudo descreveu sobre a estatística de pesca e a comercialização do caranguejo-uçá, *Ucides cordatus*, que desembarca no Município de Bragança, Pará, Brasil. A área de estudo, compreendendo três Municípios da costa do estado do Pará: Tracuateua, Bragança and Augusto Corrêa, e encontra-se situada na maior área de manguezal contínuos do Brasil. Com uma área de aproximadamente 6.000 km², entre a costa nordeste do Estado do Pará e do Maranhão (480 km de linha de costa). A área total explorada pelos tiradores de caranguejo do Município de Bragança foi de aproximadamente 877 km² dividida em: Bragança Peninsula 170 km², zona oeste 181 km² e zona leste 526 km².

O principal objetivo foi determinar o volume de caranguejo-uçá desembarcado no Município de Bragança e identificar o canal de comercialização. Os dados do presente trabalho foram coletados de janeiro de 2003 a junho de 2004. Os locais escolhidos para o monitoramento representou apenas 80% das capturas totais desembarcada no Município de Bragança. As comunidades escolhidas para o monitoramento foram Caratateua, Tamatateua, Treme e um ponto na rodovia Bragança-Ajuruteua (Taici).

Os resultados mostraram existir aproximadamente 1195 tiradores de caranguejo no Município de Bragança. Esses tiradores se deslocam para as áreas de captura andando, em montarias ou em barcos pequenos motorizados. A captura total de caranguejo-uçá desembarcada foi de 1859 ton em 2003 e de 1039 ton de janeiro a junho de 2004. Porém esse total representou apenas 80% das capturas desembarcada no Município de Bragança. A maior pressão de pesca está acontecendo na Península de Bragança. A CPUE média dessa área foi de 150 caranguejos/homem-dia e os indivíduos capturados variaram entre as classes de tamanho de 5.1 and 9.1 cm, e a média anual de largura de carapace para a Península de Bragança foi de 7.1 ± 0.5 cm. As melhores combinações encontradas através do programa ELEFA I para os parâmetros de crescimento foram $L_{\infty} = 8.58$ cm and $K = 0.20$ / ano. A probabilidade de capturar machos de *U. Cordatus* calculado pelo FISAT I mostrou que as classes de comprimento representativas das atuais capturas estão entre 6.8 e 7.3 cm. A análise virtual de coortes mostrou que a biomassa estimada para as classes de comprimento foi de 6.190 ton. Indivíduos menores que 6.0 cm e indivíduos maiores que 8.0 cm não foram representativos nas capturas. As estimativas de Z (taxa de mortalidade total) para as classes de tamanhos variaram entre 0.40 and 0.80 por ano, decrescendo com o decrescimento dos tamanhos de carapaça. A mesma tendência foi observada para a mortalidade de pesca (F) que variou entre 0.0 to 0.4 por ano.

O estudo sobre a comercialização do caranguejo-uçá desembarcado no Município de Bragança é comercializado de duas formas: a) *in natura* – caranguejo vivo e b) beneficiado – massa e pata de caranguejo. A unidade de comercialização mais usada foi a cambada, para o caranguejo vivo. Foram identificados três canais de comercialização e o principal agente mercantil foi o atacadista/varejista. A renda líquida média mensal do produtor com patrão foi de R\$ 314.00 e do produtor autônomo foi de R\$ 367.00. A diferença de preço entre o produtor e o consumidor (Markup) foi entre 32% e 67% nas feiras de Bragança e de 58% a 150% nas feiras de Belém. O caranguejo vivo desembarcado no Município de Bragança abastece o mercado local e alguns mercados em outros Estados.

A unidade mais frequente utilizada para a comercialização do caranguejo beneficiado foi o quilograma (Kg). O tipo de comercialização mais praticada foi venda direta para o patrão (PC). Os agentes mercantis identificados foram o comprador local, o atacadista e o varejista. Nessa cadeia de comercialização quatro canais de comercialização foram identificados. A renda líquida média mensal do produtor com patrão foi de R\$ 590.00 e do produtor autônomo foi de R\$ 594.00. O Markup total médio neste sistema de comercialização mostrou que o preço final pago pelo consumidor foi o dobro do preço da primeira comercialização. O caranguejo processado frequentemente foi comercializado em Belém.

Concluimos que a pesca do caranguejo no Município de Bragança produziu retorno financeiro suficiente, não só para as famílias dos tiradores de caranguejo, mas também para movimentar o comércio local. A Península de Bragança ainda apresenta uma situação favorável para a exploração sustentável porque o tamanho dos indivíduos capturados são suficientemente maior que o tamanho de primeira maturação sexual ($L_{50\%}=3.51$ cm para machos e $L_{50\%}=4.01$ fêmeas). Porém, qualquer alteração nos níveis atuais de esforço de pesca, desmatamento ou utilização de artes de pesca predatórias podem levar o estoque a situação de sobrepesca dos indivíduos grande.

CHAPTER 1 - GENERAL INTRODUCTION

1.1 Overview of the *Ucides cordatus* fishery in Brazil

Mangroves are coastal ecosystems found in the tropical and subtropical regions of the world. There are about 8,500 km of real line coast in Brazil (CNIO, 1998) of which 6,800 km, an area of approximately 20,000 km², are covered by mangroves. Mangroves in Brazil range from Amapá State (2° N) to the southern coast of Santa Catarina State, in the Araranguá River estuary (29° S) (Schaeffer-Novelli *et al.*, 1990; FAO, 1992; Kjerve and Lacerda, 1993; Melo, 1996). The states of Maranhão and Pará harbor the most extensive areas of mangrove ecosystems (Schaeffer-Novelli *et al.*, 1990; Cintron-Molero and Schaeffer-Novelli, 1992).

Of the diverse reasons to study mangroves, the fact that many communities of human beings have a traditional dependence on these ecosystems for their subsistence, may be the most significant. According to Diegues (1993), an excellent aspect in the definition of "traditional cultures" is the existence of natural resource management systems that are marked by the respect for natural cycles, and by exploitation within the support capacity of the plant and animal life. In addition, he emphasizes that these traditional systems of handling are not only forms of economic exploitation, but include a complex of knowledge, acquired as an inherited tradition, from the previous generations.

Mangroves also are defined as an ecological unit on which 2/3 of the fish population of the world depends (Canestri and Riuz, 1973). They constitute, consequently, the starting point for the nutritional sustenance of a great diversity of animals (Pannier and Pannier, 1980), many of them of economic importance. Amongst the crustaceans, the mangrove crab (*Ucides cordatus*) is considered

one of the most important components of the mangrove fauna in Brazil (Costa, 1979 and Melo, 1996). These crabs occur along most of the Brazilian coastline and are the crustacean with the highest commercial value from the Brazilian mangrove forests. The ecological importance of this species lies in the vital role it plays in the nutrient cycling within the mangrove ecosystem by finely shredding and consuming leaf litter, which is then excreted as partially digested fecal material. This material can be easily consumed by detritivores and the increased surface area allows the colonization by microorganisms (Nordhaus *et al*, 2005).

In the life cycle of this crustacean, three main phases can be distinguished: ecdise (molt), *andada* (reproduction period) and larval release. Ecdise constitutes the stage at which *U. cordatus* undergoes a complete carapace renewal in order to allow further growth, occurring generally once per year in adult individuals, and with higher frequency in young. As stated by Rodrigues and Hebling (1989) and Rodriguez (1982), there is little information about the ecdise phase, but the periodicity of the biological cycle of this species was demonstrated, with changes occurring in winter and spring. This was confirmed by observations from Alcântara-Filho (1978), Costa (1979), Maneschy (1993), and Diele (2000). On the basis of laboratory studies, Nascimento (1993) estimated that the duration of the ecdise phase and all related processes is between 15 and 20 days. However, the length of this period can vary in the natural habitat of the crab, where the diverse characteristic ambient factors of the mangrove area influence this process. The lunar cycle and the variations of the tides are factors that exert great influence on the life cycle of the crab, acting directly on the general standard of activity of this crustacean in its habitat (Diele, 2000).

Examples of studies conducted over the last 70 years, that focused on the biology and ecology of *U cordatus*, include: Physioecology of the mangrove crab, *Ucides cordatus*, in north-eastern Brazil (Costa, 1972), feeding, reproduction and behavior of the mangrove crab (Mota-Alves, 1975), contribution to the study of

biology and ecology of the mangrove crab, *Ucides cordatus* (Alcântara-Filho, 1978), bioecology of the mangrove crab, *Ucides cordatus*, in north-eastern Brazil (Costa, 1979), ecology, biology and fishes (SUDAM/UFMA, 1983). More recent studies from the Bragança Peninsula (Pará State) include: Life history and population structure of the exploited mangrove crab (Diele, 2000), feeding ecology of the semi-terrestrial mangrove crab (Nordhaus, 2004; Nordhaus *et al.*, 2005), comparative population dynamics of four fiddler crabs in the mangrove ecosystem (Koch *et al.*, 2005), population structure, catch composition and CPUE of the artisanally harvested mangrove crab *Ucides cordatus*: indications for overfishing? (Diele *et al.*, 2005) and salinity tolerance of the larval (Diele and Simiti, *in press*).

Despite the socioeconomic importance of this species, few studies on this topic have been carried out, with the prominent exceptions of Oliveira (1946) who published a brief report on the *Ucides cordatus* fishery, and Maneschy (1993), who described the social importance and functions of crab capture to crab fishermen from Pará State. Nordi (1994) portrayed the commercialization process of the mangrove crab (*Ucides cordatus*) and its influence on the decision making process of the crab fishermen in the Várzea Nova region, Paraiba State. Nishida *et al.* (1999) carried out a partner-economic and ambient appraisal of the crab fishermen on the Paraiba State coast. For the Bragança Peninsula (Pará State), Furtado *et al.* (1999) described the relationship between man and mangrove in Bragança. Glaser (2003) reported on the interrelationship of the mangrove ecosystem, local economy and social sustainability in the Caeté Estuary. Alves (2003) described the work of crab fishermen and crab processing in Caratateua (Pará State). Fontalvo-Herazo (2004) designed a participative indicator system to enable integrated coastal management for the Bragança Peninsula, and Glaser and Diele (2004) made reference to the biological, economic and social sustainability of the crab fishery in Bragança District (Pará State).

Crab fishing was never considered an important activity in the context of the Brazilian economy because it is regarded to be of small economic return on the national scale, and capture statistics for this fishery do therefore not exist. Due to the high costs, both monetary and in terms of human resources, that are necessary to produce fishery statistics, the Brazilian government has focused its efforts mainly on resources of high commercial value, such as: lobsters, shrimps and fish. However, the last five years have shown an increased concern from government environmental agencies in Brazil for fishery statistics, including for species from the artisanal fisheries, such as the mangrove crab, *U. cordatus*. This development was induced by a change in policies concerning resource management in Brazil that now attempted to include the artisanal fisheries in improvement and management programs.

Brazilian mangrove areas where these crabs are exploited, exist in the northeast region of Pará State, in the Parnaíba Delta between Maranhão and Piauí States, the entire Sergipe State, in the Guanabara and Sepetiba Bays in Rio de Janeiro, and in Iguape and Cananéia on the southern coast of São Paulo State. *U. cordatus* is caught year round with the traditional method of inserting the arm into the burrow for extraction or with the assistance of a hook. However, in some Brazilian states other forms of crab capture are used, such as the *redinha*. This technique consists of placing a small piece of polypropylene netting on the crab burrow entrance, so that the animal is imprisoned when it tries to emerge in search of food and oxygen (Botelho et al., 2000; Barbieri and Mendonça, 2004). This method, though outlawed in all of Brazil, is used with sufficient frequency to cause two types of problems: 1) females carrying eggs and molting crabs (ecdise) are not excluded from the capture, and 2) pollution is caused by abandoned gear, since the fishermen spread more than 100 *redinhas* upon arrival and can often not return to all of them. Not only do the polypropylene contraptions remain in the environment for a long time, but the trapped crabs are also lost to their natural predators.

During the last five years (from 1999 to now), drastically diminishing captures in the northeastern, southeastern, and southern states of Brazil became evident. Amongst the responsible factors were included: indications of overfishing, the use of depleting practices, and commercialization of processed *Chelae* crabmeat. The high demand for Chelae meat has lead fishermen to merely detach the Chelae from captured crabs and to abandon the rest of the carapace in the mangroves. This practice has long been outlawed, but with legislation showing little effect, it is now widely used in areas where processing is common (Barbieri and Mendonça, 2004).

Along the Brazilian coast, fisheries are directly responsible for about 800,000 jobs and an additional four million indirect jobs. The Special Secretariat of Aquaculture and Fisheries (SEAP) has registered more than 21,000 artisanal fishermen, however, the number of crab fishermen is unknown as they are not registered as such. Independently of the official estimate, it can be said that fishing is important for the subsistence of an enormous number of families. Brazilian policy provides that all professionals must register with the appropriate Professional Board, in order to receive pensions, health and unemployment insurance and other social benefits. Unfortunately, crab fishing is not a recognized profession and so registration is impossible. Since Professional Boards reject to recognize crab fishing as an official profession, crab fishing is considered an activity with poor professional prospects, where less than 10% of the actors (1.69%) can receive INSS (Instituto Nacional do Seguro Social) support and other benefits (Silva, 2004).

Some authors have made reference to the income generated by crab fishermen, however, no studies about the commercialization chain of the mangrove crab have been conducted to thoroughly examine this industry and those depending on it. Past studies were limited to characterizing fishing communities according to the amount of fishing, level of education, number of people in the family, and

other particularities of the social situation. Studies on job and income generation, with emphasis on characterizing the economy, have rarely been conducted. Economic information based on the commercialization chains is equally important for fish populations, as is information on their ecological processes and biological characteristics. Combining both aspects of a fishery would lead to administrative resolutions that not only consider the biological sustainability in management plans, but also the economic efficiency of the resource exploitation.

Fish Stock Administrations base their regulatory decisions on total catch data and the levels of exploitation. A deepened knowledge of the characteristics of a fishery and its role in society is necessary to contribute to the formulation of effective public policies and fishing laws (Fonteles-Filho, 1989). With regard to the management of fish stocks, it is indispensable to incorporate economic data and to thereby redefine models used for fish stock assessment. This vision will contribute to prevent that errors committed in the past, are not repeated in the future. Thus, parallel with the formulation of rules for the use of the economic instruments, criteria for resource exploitation limits for fish stocks need to be constructed, among all other things to be considered.

1.2 Current status of research on the crab fishery in Bragança

The present study was carried out within the context of the scientific MADAM Project (Mangrove Dynamics and Management). The MADAM Project was a bilateral cooperation between Brazil and Germany with the overall aim of investigating the mangrove ecosystem to create a scientific basis, which would explain the links and interactions between persisting ecological, sociological and economic circumstances (Berger *et al.*, 1999; Dittmar, 1999; Schneider and Saint-Paul, 2002). The project was developed on the Pará State coast, Brazil,

over a ten-year period. The study area was situated on the Bragança District coast, encompassing the Bragança Peninsula and the Caeté Estuary.

Among other objectives, the biology of the mangrove crab, *U. cordatus*, was investigated, focusing on crab population structure, life cycle (reproduction, larval stage, growth) (Diele, 2000, Diele *et al.*, 2005, Diele and Simith, in press), and feeding ecology (Nordhaus, 2003; Nordhaus *et al.*, 2006) and commercial exploitation (Glaser and Diele, 2004; Diele *et al.*, 2005). The growth parameters determined for *U. cordatus*, on the Bragança Peninsula, indicate that the species is rather slow-growing and long-lived. Its maximal life span of more than ten years is manifold higher than that of other brachyuran species inhabiting the mangrove forest of the Caeté Estuary (Koch, 1999; Diele, 2000). At Furo Grande the total mean annual crab density and biomass was 1.7 indiv./m² and 142 g/m², respectively, and 0.4 indiv./m² and 53 g/m² for the large exploited males with a carapace width ≥ 6.5 cm (Diele, 2000; Diele *et al.*, 2005). The exploitable biomass per year for the yield of these large males was estimated at 1200 t for the Bragança Peninsula (Diele *et al.*, 2005). However, the total landings in Bragança District are not well known. The official statistic (IBAMA, 2004) indicated that in 2003, 900 t of crab were landed in Bragança District.

The capture size of crabs landed at Furo Grande has shown that traditional crab fishermen prefer to capture large males (Diele, 2000; Diele *et al.*, 2005). Not a single female was encountered in the capture and 96% of the measured specimens had a carapace width of 6.5 cm or larger (Diele, 2000; Diele *et al.*, 2005). On the Bragança Peninsula, crab fishermen capture crabs by either pulling them out of their burrows by hand, or, when burrows are too deep, with a hook tied to a 1.5 m long stick (Diele, 2000). The exact number of crab fishermen in this area was not known. Glaser (2003) estimated that 42% of the resident household in the 21 rural communities of the Bragança District are crab fishermen. A crab fisherman generates a net income of about R\$ 176.00 per

month (Glaser and Diele, 2004). Data from the study on crab commercialization by Glaser and Diele (2004) reflect exclusively the activities of crab fishermen landing in Furo Grande (in the distal part of the Bragança Peninsula).

In 2005, the entire Bragança District coast was instated as a Marine Extractive Reserve (RESEX). The RESEX “Caeté-Taperaçu” in Bragança District has an exceptional status among the newly established reserves, as the Caeté River estuary was the main study site of the long-term cooperative Brazilian-German research project MADAM, over the last decade. The creation of the RESEX is accomplished in four distinct steps, of which the first two have been supplemented by the efforts of the MADAM project and Brazil’s official program for the collection of data on fisheries (Statpesca/IBAMA):

1. Basic mangrove research;
2. discussion with stakeholders about the management structure of the RESEX;
3. formulation of a management plan using information from steps 1&2;
4. implementation of the RESEX management plan.

The data presently available to initiate step three may, however, be limited to some extent and need to be further verified before the result are implemented.

The present level of fishing pressure appears stable and scientific results from the MADAM Project could provide some information needed to make a management plan based on the ecological sustainability of the crab fishery. However, the fisheries monitoring program of the MADAM project (daily landing data from 1997 to 2006) was conducted only at Furo Grande, a major landing point in the distal part of the peninsula, and may thus not be representative for the entire Bragança District coast or even for the entire peninsula. Brazil’s official program for the collection of data on fisheries (Statpesca/IBAMA) also collects data on the Bragança District coast at regular intervals. However, sampling is carried out only twice a month at one location in Bragança District and

consequently extrapolated to a monthly average for the entire district. The same sampling design is used in all of Brazil and is not based on prior studies for optimal sample size and frequencies in each location. Therefore, the information collected by the MADAM Project and by Statpesca for fishery statistics in Bragança District may only reflect the local situation at Furo Grande. Data for the fishery situation on the entire peninsula and Bragança District are needed in order to verify and implement the MADAM Project data, including the ones obtained by this study, in the management plan of the RESEX “Caeté-Taperaçu”.

An additional confounding factor may be that all crabs landed at Furo Grande are destined for the live crab market (as opposed to the processed crabmeat market) and so selectivity towards larger individuals is acting on the catch structure. Furthermore, though the present level of fishing pressure appears stable the level of the applied fishing effort in the area is not known and so no statement about the sustainability of a possible effort increase can be made. To allow a reliable evaluation of the crab fishery and those depending on it more information about the fishery itself and the markets it supplies, is needed.

To measure the level of crab exploitation, methodologies described by Gulland (1966), Sparre & Venema (1992) and the FAO (1982) can be used. All three authors emphasize the importance of having accurate knowledge of natural populations in order to provide recommendations for sustainable exploitation. Gulland (1966) contemplates the statistical theory relevant to develop sampling strategies, using data collections of catch and fishing effort, as well as data on the length composition of the catch. FAO (1982) presents the basic statistical theory used for the planning and implementation of programs attempting to sample fish landings. Sparre & Venema (1992) summarize and propose a method to estimate the total catch in different types of fisheries, based on sampling both the fishing effort and the catch in selected localities.

These methodologies focus on monitoring systems and the attainment of data series for the capture, the fishing effort applied and size measurements of samples from the capture. With data series of the captures and a known fishing effort, the maximum sustainable yield (MSY) of this fishery can be estimated and the fishing effort controlled accordingly. Sample data (size measurements) from the captures can be used to monitor the growth parameters of the stock that indicate changes in the structure of the population. When identified early, the appropriate changes can be made in the management plan. Mortality parameter estimates of a population can aid fishery investigators in making management decision when the MSY has not yet been determined.

An important characteristic of a RESEX is, that the local population is incorporated in the decision making process that determines resource use limitations in the range of the reserve. In order to support the local population in their decision making process and to offer suggestions which combine their own interests with a sustainable use of the resource, the situation of the stakeholders needs to be investigated. A thorough analysis of the commercialization system can uncover how profits could potentially be redistributed or increased for individuals involved in the commercialization. To answer questions related to the commercialization system in place, the applied concepts of micro economy in family agriculture described by Reis (1997), Hoffman (1987) and Inhetvin *et. al* (1999) can be used. The basic principle of the three authors is to monitor the price of the product on the various levels of commercialization, to describe the possible channels of commercialization, identify the mercantile agents involved and costs produced during the commercialization.

This study aims at gathering information on the fishery of *U. cordatus* by monitoring various locations in Bragança District that have demonstrated a high crab landing volume. The applied fishing effort will be measured and the situation of the exploited stock evaluated. In addition, monitoring of prices on the different

levels of commercialization will clarify the situation of the mercantile agents involved and give an estimate of the market size. Both data sets are aimed to complement and verify information gathered previously and to assist in the formulation of a management plan (step 3) for the RESEX “Caeté-Taperaçu”, aimed at preserving or instating sustainable exploitation levels.

1.3 Objective

The main objective of this study was to determine the yearly volume of crab landings in Bragança District and to identify the channels of the crab commercialization in order to provide information towards the formulation of a management plan for the RESEX “Caeté-Taperaçu”, aimed at preserving or instating sustainable exploitation levels.

Individual research questions include:

- 1) What is the monthly capture of mangrove crabs landed in Bragança District?
- 2) What contribution do crab landings from the Bragança Peninsula make to the total capture?
- 3) What markets (local, regional and national) does the Bragança capture supply?
- 4) What are the visible and invisible characteristics of this market?

The study design aims to test the following hypothesis that developed within the MADAM Project's experience in the area:

- 1) The available data on total crab landings in Bragança District are not accurate. (Chapter 2)
- 2) The profit margin for the crab fishermen can be increased without increasing the fishing effort. (Chapter 3)

The different study aspects that aimed to fulfill the study objective and answer the individual research questions were organized in the following manner:

Chapter 2 – This chapter answers questions 1 and 2, focusing on all aspects of the crab fishery. The analysis of the data presented in this chapter provides information on the profile of the crab fishermen, the vessels used, the main points of crab landing, the areas used for crab capture, the total landings in Bragança District, the fishing effort applied, the CPUE, crab population structure, as well as an update of the growth parameters (K and L_{∞}). In addition, mortality parameters were estimated. For the majority of the results, data from the Bragança Peninsula were compared with areas outside of the Peninsula. Crab fishery data from 10 years of research by the MADAM Project for the Furo Grande landing point on the Bragança Peninsula are available, but no data for the entire peninsula and areas outside of the peninsula existed. This chapter provides crab fishery data for the entire Bragança District and thereby completes a general objective put forth by the MADAM Project for the final phase of the project.

Chapter 3 – This chapter covers all aspects of crab commercialization, providing answers to questions 2 and 3. The analyzes of the data collected supplies information on the units of commercialization, commercial transactions, the mercantile agents involved, the channels of commercialization, the costs, the marketing margins, markup and the target markets involved in the local crab commercialization. The data analysis divides crab landings from Bragança

District into those intended for the live crab markets and those for the processed crabmeat markets.

Chapter 4 – This chapter presents a review on the legislation for managing crab fishing and crab commercialization.

Chapters 5, 6 and 7 – General Conclusion, literature references and appendices.

The research was conducted in Bragança District, Pará State, Brazil, between January of 2003 and June of 2004.

1.4 Study area

The study area was situated in a continuous mangrove area spanning three districts of the Pará State coast: Tracuateua, Bragança and Augusto Correa. With a size of about 6.000 km², the area between the northeastern coast of Pará State and the northwestern coast of the Maranhão State (480 km of coastline) is one of the largest continuous mangrove systems known (Herz 1991). The study area had a total length of 100 km and extended between the Maiau (46°32'16" W, 00°43'18" S) and the Apeu (46°75'11" W, 00°04'17" S) estuaries (Figure 1) (Souza-Filho, 2000; Melo, 1996). It is part of the largest and most preserved tropical region of the world, the Amazon region. The coast is extremely irregular, with innumerable bays and estuaries. This sector of the Brazilian coast is characterized by a system of semidiurnal macro tides. The range of the average tidal amplitudes found in the area lies between 4 m (minimum) and 8 m (maximum), and tidal currents with maximal speeds above 4 m/s were registered in the Golfão Maranhense (Rebelo-Mochel, 1997). Mangroves are confined to the warm and humid equatorial climate, with well defined rainy and dry seasons and an average annual precipitation around 2,500 mm. The air temperature varies

between 25° and 27° C, with a relative humidity of 80-91% (Martorano *et al.*, 1993).

The vegetation of the region consists of typical mangrove plants, represented by specimens of *Rhizophora mangle*, *Avicennia germinans* and *Laguncularia racemosa* (Mehlig, 2001). Tree height and vegetation type are directly related to the altimetry of the land, influenced by the tides and the type of sediment present. The timeframe of sampling for this area included two rainy seasons (December to May) and one dry season (June to November). This area suffers a large salinity gradient along its extension, with salinities increasing from upriver, towards the ocean (Martorano *et al.*, 1993; Souza-Filho & El-Robrini, 1997 a,b). The mangrove sediment of the intertidal is composed of organic mud deposits dating back to the Holocene. Silt and fine sand dominate in this layer, whose depth varies between 300 and 600 cm. Organic material is marked by its dark gray coloration and the water content of the sediment is high (Souza-Filho 1995, Souza-Filho *et al.*, 1996).

For a better understanding of the study area it is necessary to refer to the administrative division of Brazil. Brazil is divided into 26 states, where each state has its own capital and is subdivided into several districts. Each district has a main city and several smaller ones (villages). This study was carried out in Bragança district, situated on the northeastern coast of Pará State (the capital is Belém). Bragança district's main city is Bragança City. The coastal zone of the Bragança district is formed by the Bragança and Taperaçu Peninsulas. The Bragança District has a current population of 93.779 inhabitants: 56,572 live in urban areas 37,207 in rural areas. According to Fundacao Nacional de Saude (FNS, 2002), 17,567 of the urban dwellers live by the seaside. The distribution of personal income indicates that 19% of the residents receive minimum wage, 14% between one and five times the minimum wage, and only 0.5% of this population earns more than ten times the minimum wage (IBGE, 2004).

The road (Bragança-Ajuruteua Road) connecting Bragança City to the coastal zone, allows intense exploitation of the Bragança Peninsula by crab fishermen (Costa *et al.* 1993 and 1997, Glaser and Grasso 1998, Diele 2000). The scope of this study is limited to activities of crab fishermen who are resident in the Bragança District. The study area includes all mangrove areas in Bragança District (between the Maiau and Apeu estuaries) which are exploited by these crab fishermen.

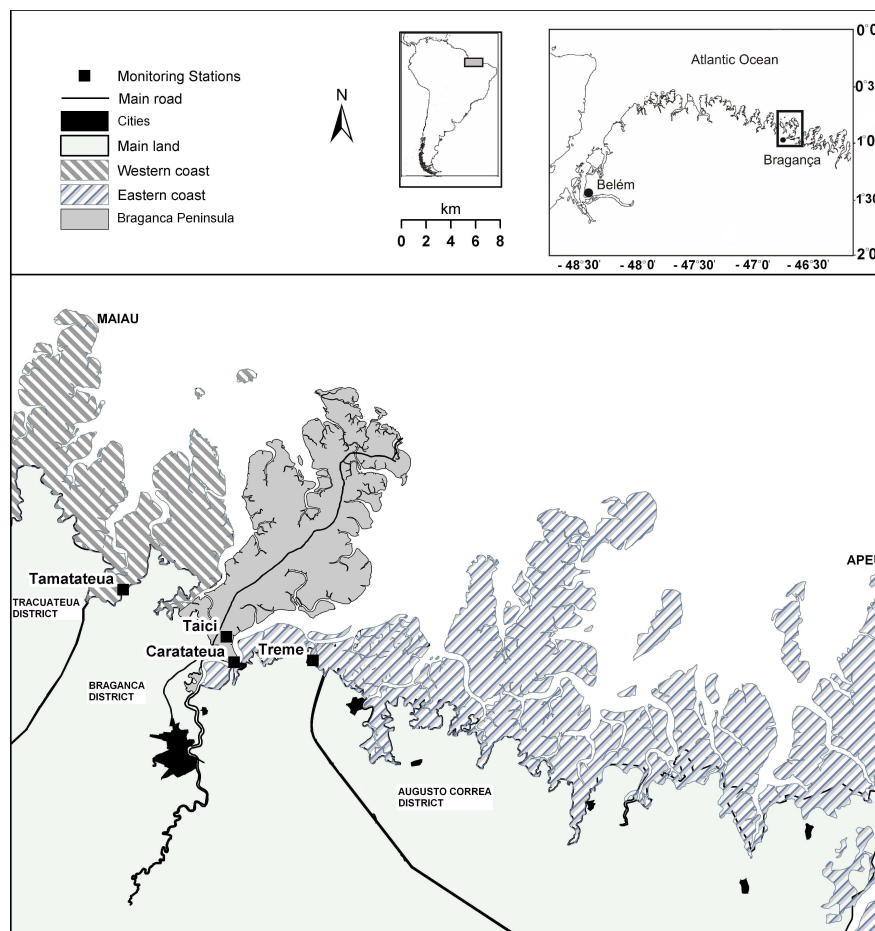


Figure1: Study area. Extension of mangrove forest along the coastline of the Tracuateua, Bragança and Augusto Correa Districts. Source: GIS/MADAM/2005.

CHAPTER 2 - FISHERY STATISTICS

2.1 Introduction

Reliable statistics on total fish catch constitute the basic information needed to determine a strategy for fish exploitation, and subsequent development of management plans and public policies relevant for a steady and sustainable fish supply. This also applies to the mangrove crab, *Ucides cordatus*.

Manuals on fisheries statistical theory, that reference collections of fish landing data and estimates of total catch, are published by FAO (Food and Agriculture Organization of the United Nations). As an example, Gulland (1966) contemplates the statistical theory relevant to develop sampling strategies, using data collections of catch and fishing effort, as well as data on the length composition of the catch. Bazigos (1974) synthesizes the statistical theory applied to the collection and analysis of fisheries information, including a series of practice examples. Brander (1975) formulated the basic data to be collected in a program of data collection on fish, as well as directions for the analysis and publication of this information. FAO (1982) presents the basic statistical theory used for the planning and implementation of programs attempting to sample fish landings. Caddy & Bazigos (1988) produced an implementation manual for fisheries data collection programs, under conditions where few human and financial resources are available. They included step-by- step directions for the application of basic statistical theory on this type of data. Sparre & Venema (1992) summarize and propose a method to estimate the total catch in different types of fisheries, based on sampling both the fishing effort and the catch in selected localities.

Until 1967, the generation of fisheries statistics in Brazil was the responsibility of a now extinct government body: Statistic of Production (SEP), Ministry of Agriculture. This authority was responsible for processing the landing data supplied by IBGE (Instituto Brasileiro de Geografia e Estatística) and others institutions. Import and export data for the fish trade were collected and processed by the Ministry of Agriculture itself. After 1967, another now extinct government body SUDEPE (Superintendência de Desenvolvimento da Pesca), instituted a Board of statistic advisors with the objective of trying to improve the collection, analysis and dissemination of fisheries data. In 1968, a partnership program with FAO was created, and from the middle of the 1970's, this was the main source of fisheries data in Brazil. The program was carried out in this form until 1978 when the financial and technical support from FAO terminated. After this point, the fisheries statistic program was not continued at the same level and had lost its priority status within the institutions. This development resulted in a deep gap in official information on Brazilian fisheries, primarily from the years 1990 to 1994, compromising the decisions making process, paramount for fisheries conservation and the development of the fisheries management plans (Aragão, 1997).

The estimate of the total national catch for the period from 1990 to 1994 was determined by the IBAMA (Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis). The estimate was based on total catch data collected between 1986 and 1989, to whose arithmetic mean was added the catch data of the main fished species collected by the Permanent Groups of Study of IBAMA, project ESTATPESCA in the region of northeastern Brazil, projects from the CEPSUL (Centro de Pesquisa e Gestão de Recursos Pesqueiros do Litoral Sudeste e Sul), CEPERG (Centro de Pesquisa do Rio Grande do Sul) Fishery Institutes on the southeastern and southern coast of Brazil and in the north of Brazil, the project from the CEPNOR (Centro de Pesquisa do Norte) Fishery Institute (Aragão, 1997; IBAMA, 2003).

Since 1995, IBAMA has promoted the improvement of the national fishery statistics data base. However, in some states monitoring of fish catch is still insufficient, as is the case in Para State. In 2003, the volume of fish catch registered in Para was 154.546 t (fish, crustaceans, clams and others), representing 48.9% of the total catch in Brazil and thereby occupying the first place in all national territory. It is possible that this estimate represents only a fraction of the true catch volume in this state, because consumption by the fishermen was not considered. The total regional catch of crustaceans (mainly shrimp, lobster and crab) for Para State reached a volume of 10,593.5 t, divided among the artisanal fisheries (7,075 t) and the industrial fisheries (3,519 t) (IBAMA, 2004) (Figure 2).

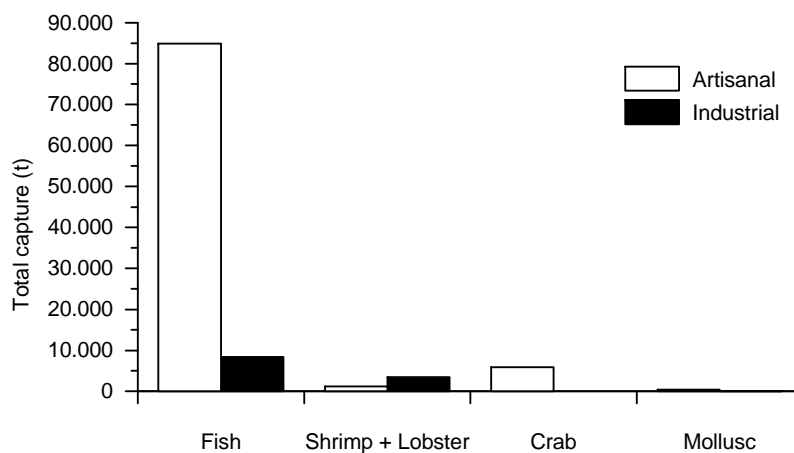


Figure 2: Official fishery statistics, Pará State for the year 2003 (IBAMA, 2004).

The total capture of mangrove crab (*Ucides cordatus*) in Pará State reached a maximum of 8,152 t in 1990, according to data from CEPNOR/IBAMA (2004), with a decreasing trend in the years following and a subsequent rapid increase from 2001 onwards. These data do not, however, reflect the true numbers because the estimate is based on very few data sets that were averaged for a

national statistic. Unfortunately, the mangrove crab was never considered a fish resource with significant economic return, as is the case for the other crustaceans, like shrimp and lobster (Figure 3). Crab fishing is carried out on the entire coast of Pará State, with the highest landings observed in the Bragança, Maracana, Quatipuru, Sao Caetano de Odivelas and Vizeu Districts.

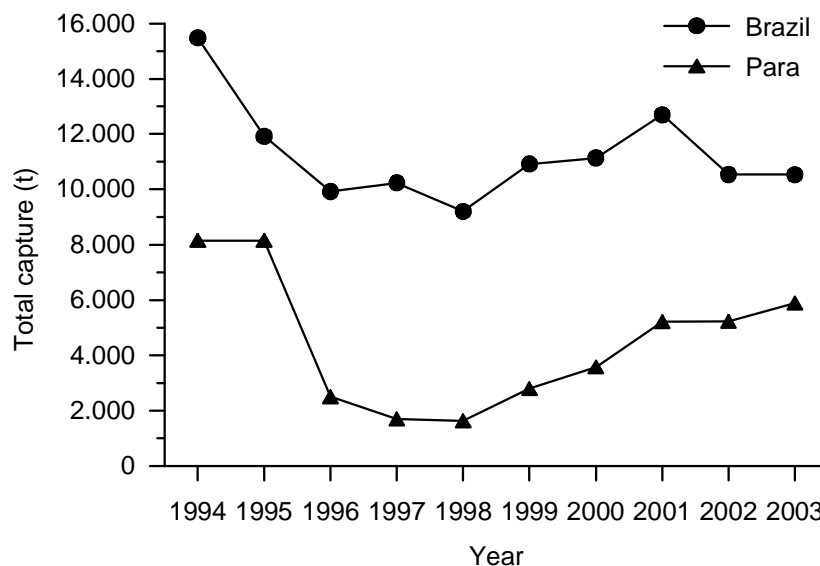


Figure 3: Mangrove crab, *U. cordatus*, fishery statistics for Brazil and Pará State, 1994–2003 (CEPNOR/IBAMA, 2004).

A reliable fish stock assessment, among others aspects, requires knowledge of the life cycle and distribution of the species involved (King, 1995). To efficiently monitor fish it is also necessary to use current information to generate population parameters and to gain understanding of the fishing dynamics (Hilborn 1985, Hilborn and Walters 1992). Exploitation of a particular fish stock is always limited to a certain length and age group which constitutes the only part that is

accessible to capture. The study of annual variances in the population abundance, in particular the population fraction under fishing pressure, is based on data of the number and weight of individuals that comprise the catch. The data is obtained at regular time intervals in the areas where fishing occurs. It is practically impossible to determine the absolute abundance of fish populations. The usual alternative is to resort to abundance indices, amongst which the CPUE (Catch per unit effort) is most frequently used (Fonteles-Filho, 1989). The use of research data for the elaboration of public politics has become common place and is an important step in materializing co-management structures.

The main objective of this chapter is to present information on the total volume of mangrove crab landings in Bragança, the fishing effort applied, CPUE (catch per unit effort) and the crab population structure, as well as to up date the known growth parameters (K and L_{∞}). In addition, to estimate the total mortality coefficient (Z), the natural mortality coefficient (M) and the exploitation rate (E) of the mangrove crab, *U. cordatus*, captured on the Bragantina coastal zone by artisanal crab fishermen.

2.2 Methodology

This study was initiated within the frame of the MADAM (Mangrove Dynamics and Management) Project. Preliminary studies indicated that crab fishing occurs frequently along the Bragança-Ajuruteua road and in the coastal communities fringing the Bragança Peninsula. To identify the optimal number and placement of monitoring stations, seven communities were visited in total, and the three communities with the highest volume and frequency of crab landings were chosen for this study. The communities chosen for monitoring were Caratateua, Tamatateua, Treme and the Bragança-Ajuruteua road. In Caratateua and Treme, two points to collect data were identified. In Tamatateua, three points were identified: two local ports and one point on the road between Tamatateua and Bragança. At Taici Bridge (Bragança-Ajuruteua road) an additional monitoring point was established.

From January of 2003 until June of 2004 data were collected to serve as a base for the present work. Data were extracted from the following sources: 1) data collection in the field: a) landing data and, b) size of captured crab, and 2) data collection for summary of crab legislation in Brazil.

2.2.1 Data collection in the field

a) Landings

Two survey forms were created to ensure the consistency of the information recorded in each interview. One of these forms was applied in the ports of the community and the other, for stations on the road. It was necessary to use 2 different forms because interviews on the road had to be kept shorter to avoid

traffic problems. The survey form utilized in the communities contained the following questions:

- Date
- Type of transport – canoe, boat, other
- Number of crab fishermen
- Technique of capture
- Commercial unit utilized – *cambada*, basket, net, sack, etc
- How many crabs per unit
- How many units
- Sell to the market or to the boss
- Location of capture - Bragança peninsula or outside of the peninsula
- The name of the location of capture
- Work start time
- Work end time
- Travel time
- Net work time
- Price per unit

The form utilized on the road included the following questions:

- Date
- Type of transport – bicycle, bus, truck, other
- Number of crab fishermen
- Technique of capture
- Commercial unit utilized – *cambada*, basket, net, sack, etc
- How many crabs per unit
- How many units
- Sell to the market or to the boss;

- Location of capture - Bragança Peninsula or outside of the peninsula;
- The name of the location of capture
- Price per unit

For the data collection, 13 local students were contracted and trained appropriately. The data were collected daily from January 1, 2003 to June 30, 2004. The student's work was controlled weekly, and a monthly meeting was held with all participants for a general exchange of information and to offer help or suggestions. At the monitoring point on the Bragança -Ajuruteua Road a shed was built to shelter the data collectors and to help the commuters to recognize this point as an official data collection point.

To prepare the local community for the process of data collection and to ensure their collaboration, information on the process and the use of the data collected were disseminated via community radios, meetings with the communities, large posters that were fixed in public places, and pamphlets that were distributed in schools and to people in cars and buses. The objective of this was to inform the population about the monitoring starting date and to invite and encourage them to participate. All 13 students and bus drivers used t-shirts and caps for identifying them as project participants.

Simultaneously, all known crab fishing localities were visited and recorded for future geographic reference. In addition, all crab fishermen encountered in the communities or at the ports were registered to obtain the total number of crab fishermen active in the area.

A database was created in the Access computer program for rapid processing of the incoming data.

The information obtained through the survey forms was used to locate the fishing areas, identify the capture systems, and to estimate total monthly catch, fishing effort, CPUE (capture per unit effort) and the price at first sale. To identify the exact location of the crab capture sites, again, the information from the survey forms was used. Information on the capture systems was categorized into the type of fishing gear and boat used. The fishing effort was determined as the total sum of the efforts in one month, and the unit used was “number of crab fisherman x number of days”. The CPUE was determined by dividing the total crab production by fishing effort, and the unit used was “number of crabs / number of man-days”.

b) Size of captured crab

The collection of biometric data from landed individuals was initiated in March of 2003 and continued until June of 2004. 3 of the 13 students were selected and trained to execute the measurements twice per month. The width of each crab carapace was determined with a caliper ruler. Each student measured 224 crabs from four locations on each sampling occasion. From each location, four *cambadas* were randomly chosen and measured. However, when particularly small or large individual were spotted, they were also measured and recorded separately.

The growth study based on the monthly carapace width data of males, allowed estimates of the growth parameters for *U. cordatus*. The biological information available from literature sources gave the necessary support to evaluate the results. In the seasonal growth equation, the values for the seasonal growth amplitude (c) and the annual period of slow growth (Wp) were set to zero, due to insufficient information available on the natural oscillation of these factors.

The data were used to establish the size frequencies for the fished portion of the male crab population. Growth parameters, L_{∞} (asymptotic mean width maximum) and K (growth rate coefficient; determines how quickly an individual reaches L_{∞}), were estimated using different methods in order to compare these values to values from prior studies on the same crab population. Information on the biological life history of *U. cordatus* was taken in part from Diele, 2000 and Vales, 2003.

The parameters of the Von Bertalanffy growth curve were estimated with four different methods included in the FISAT - FAO-ICLARM Stock Assessment Tool computational package (Gayanilo, Sparre, Pauly, 1996; Gayanilo and Pauly, 1997). The ELEFAN I method (Pauly and David, 1981) was used to identify the (seasonally oscillating) growth curve that "best" fits the set of width-frequency data, using the value of R_n (goodness of fit index) as a criterion (Gayanilo and Pauly 1997). The Shepherd method uses the same assumptions and process as the ELEFAN I method but uses constant size classes for the estimation of L_{∞} and K . The Wetherall's method (1986), as modified by Pauly (1986), uses a pool of width-frequency data to estimate L_{∞} and Z/K for a steady state population. The Bhattacharya's method (1967) and Sparre and Venema (1992), infer growth from the apparent shift of the modes or means in a time series of width-frequency data. By this method individual cohorts (normal distribution) are identified within the population and the growth curve parameters can be deduced (Sparre and Venema, 1992).

The total mortality coefficient (Z) was estimated from the lengths-converted capture curve, using the Bevert and Holt (1956) formula, the Ault and Ehrhardt (1991) formula and the Ssentgo and Larkin (1973) formula. The formulae utilize maximum length data and mean length of individuals from the captures and the growth parameters, as suggested by Sparre and Venema (1992).

Beverton and Holt` method (1956):

$$Z = \frac{K (L_{\infty} - L_{med})}{(L_{med} - L^{'})}$$

Ault and Ehrhardt` method (1991):

$$Z = \frac{(L_{\infty} - L_{max})}{(L_{\infty} - L^{'})^{Z/K}} = \frac{\{Z (L^{'} - L_{med}) + K (L_{\infty} - L_{med})\}}{\{Z (L_{max} - L_{med}) + K (L_{\infty} - L_{med})\}}$$

Ssentgo and Larkin` formula (1973):

$$Z = \frac{n K}{[(n + 1) \{ \ln(L_{\infty} - L^{'}) - \ln (L_{\infty} - L) \}]}$$

where

K = growth rate coefficient

L_{∞} = maximum theoretical length

L' = a length not smaller than the smallest length of fish fully represented in catch samples

L_{med} = mean width of the crabs larger than L'

L_{max} = maximum width found in the samples

n = number of samples, and

\ln = natural log.

The coefficient of natural mortality (M) was estimated using the formula proposed by Rikhter and Efanov (1976), which considers the age ($Tm_{50\%}$) related to the mean width at first gonad maturity:

$$M = 1.521 / (Tm_{50\%}^{0.720}) - 0.155$$

Values for $Tm_{50\%}$ were calculated from results by Vale (2003) that consider $L_{50\%} = 3.51$ cm for males.

The fishing mortality (F) is the difference between Z and M , while the exploitation rate (E), described in Baranov (1918) and Sparre and Venema (1992), is given by:

$$F = Z - M$$

$$E = F/Z$$

The growth parameters and the mortality estimate were used for virtual predictive analysis of cohorts, according to Jones` model (1984). The size-weight relationship was calculated using values for *U. cordatus* from Diele (2000):

$$Y = 0.4489 x^{2.9533}$$

2.2.2 Statistical Analysis

The catches per unit effort estimated for the peninsula and for areas outside of the peninsula were tested for significant differences using the analysis of variance (ANOVA). For non-normal distribution the Kruskal-Wallis post hoc test was applied. In order to compare mean capture sizes from different sites in the study area the t-Student test was applied.

2.2.3 Data collection for summary of crab legislation in Brazil (see chapter 4)

All available information on crab legislation was analyzed and summarized for this study. Results were used to construct options for viable mangrove management.

2.3 Results

2.3.1 General description of mangrove crab fishing in Bragança

2.3.1.1 Crab fisherman

In the frame of this study, a crab fisherman was defined as a professional whose main income is generated by capturing and selling crabs. A total of 1195 crab fishermen were identified in the Bragança coastal communities. The highest number of crab fishermen was found to live in the Treme community, while the lowest number originated from Bragança City (Table 1).

Table 1: Total number of crab fishermen registered in Bragança District per community during 18 months of survey (2003–2004).

Community	Number of crab fishermen
Acarajó	200
Bacuriteua	180
Bragança	15
Caratateua	250
Tamatateua	250
Treme	300
Total	1195

The Peninsula was exploited by 80, 15 and 2% of the crab fishermen from Caratateua, Treme and Tamatateua, respectively (Table 2 and annex 1). The crab fishermen from Acarajo, Bacuriteua and Bragança who entered and left the mangrove areas by the Bragança-Ajuruteua road, were monitored at Taici Point and so all (100%) were registered to have been exploiting the peninsula. The greatest numbers of interviews with survey forms conducted in one month were 1757, 4241, 2288 and 1725 for Caratateua, Taici, Tamatateua and Treme, respectively.

Table 2: Total monthly numbers of interviews in 2003, mean and standard deviation. Peninsula: percentage of crab fishermen working on Bragança Peninsula.

Landing Point	Number of interviews	Peninsula	Outside of the peninsula
	mean	%	%
Caratateua	1221±299	80	20
Taici	2034±807	100	0
Tamatateua	1155±352	2	98
Treme	775±389	15	85

The crab fishermen utilized various forms of transport to reach the mangroves. The crab fishermen from the Caratateua, Tamatateua and Treme communities used their local ports to embark to the mangroves in canoes or motorized boats. Some merely walked to the mangroves adjacent to the community. The crab fishermen from Bacuriteua, Acarajó and Bragança moved by bus, bicycle and

truck (those with a boss) along the Braganca-Ajuruteua road, from where they continued by canoes, boats or walking into the mangroves.

The decision of where to attempt crab capture that day, was made among fishermen sharing a vessel for transport. This decision was primarily based on information obtained in casual talk in the harbor or from other group members about the frequency with which certain areas had been visited by others in the recent past. Areas known not to have been visited recently were favored. This decision making process was common for all communities in the area. The data indicated that the highest number of crab fishermen disembarked on Friday and Saturday of each week in the Tamatateua ports and at Taici point. On these days, the mean (\pm SD) number of crab fishermen were 140 ± 76 for Friday and 115 ± 54 for Saturday at Taici point. The count in Tamatateua showed 80 ± 25 crab fishermen on Friday and 82 ± 34 on Saturday. During the days of crab reproduction (andada) the number of crab fishermen at Taici point were the highest from all days in the study period (18 months). In Caratateua, Monday and Saturday were the days with the least number of crab fishermen, with 35 ± 20 and 32 ± 21 , respectively. The number of crab fishermen in Treme remained constant throughout the week. Sunday was the day with the least number of working crab fishermen for all areas (Figure 4).

The capture of the mangrove crabs was carried out by the artisanal fishing system, using two types of methods: hook and/or arm. During the ecdise period (May to August) the hook was used as the primary method of capture. At this time the crab is in deeper burrows and the crab fisherman can no longer reach the crab by hand. The hook also assisted the crab fishermen to carry the *cambadas* from the mangroves to firm land.

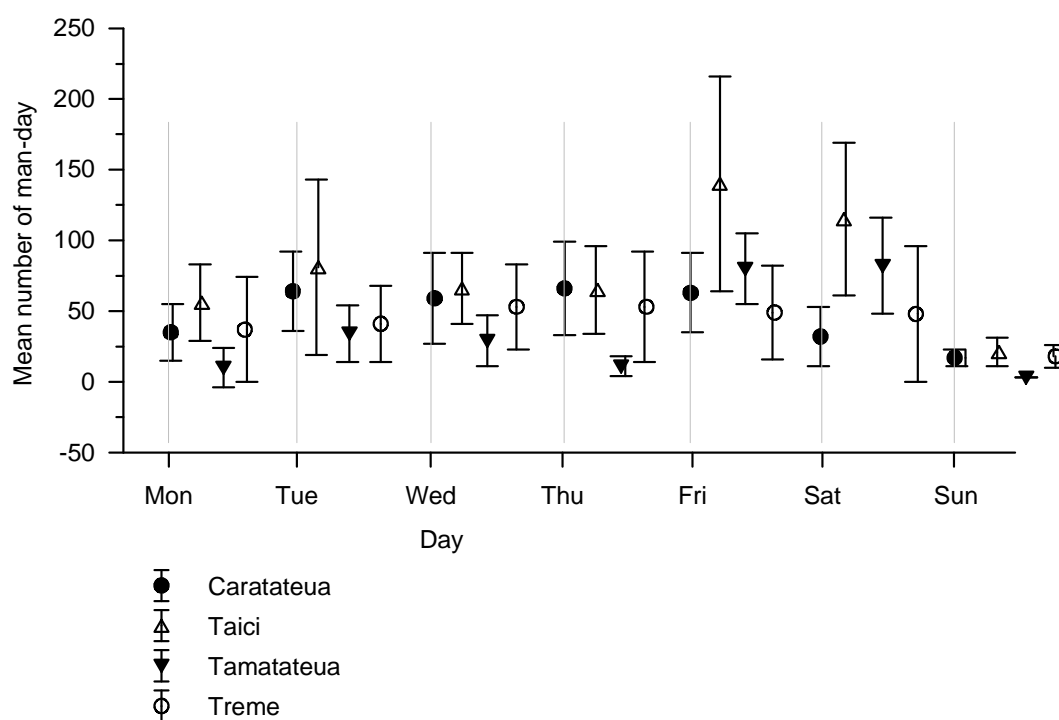


Figure 4: Number of crab fishermen on each day of the week at the monitoring points. Mean of 18 months, 2003–2004 ($n=62492$). Error bars: standard deviation.

2.3.1.2 Main landing points

Mangrove crab landing was carried out in diverse ports of the coastal communities and along the Braganca-Ajuruteua road. From the total amount of mangrove crab captured in the study area (2898 t from January 2003 to July 2004), 31% was landing in the Braganca-Ajuruteua highway, 26% in Treme, 22% in the ports of Caratateua and 21% in Tamatateua. The Braganca-Ajuruteua highway facilitates the access of the crab fishermen to the mangroves of the Bragança peninsula (Table 3).

Table 3: Percentage of total crab catches landed at the individual landing points/ports for 18 months of survey (2003 and 2004).

Locality/ Landing Point		%
Bragança - Ajuruteua road	Furo Grande Bridge, Furo da Ostra Bridge, Furo do Meio Bridge, Furo do Café Bridge, Trapeval Novo, Cajueiro	31
	Caratateua community	16
	Pedreira Port	6
	Tamatateua community	15
Treme community	Atalaia Port	4
	Trapeval Port	1
	Moacir Port	25
	Treme Port	2
	Aciteua Port	

2.3.1.3 Fishing fleet

The vessels used by the fishermen served solely to carry them to the fishing areas and to return them and their catch to the landing ports. Two types of boats were used for transport: man power canoes and small motorized boats. The majority of the canoes and the small boats were property of the boss and not of the crab fishermen, but belonged to a small group of individuals exploiting this situation.

In order to classify and group the boats, the CEPNOR-IBAMA (2003) classification system was used. By identifying physical characteristics of the boats the information was condensed into two types of groups:

a) Canoe (Mon): man powered vessel, made entirely of wood, known commonly as hoof, man powered vessel, or *montaria*. The length is between 2 and 7 m.

b) Small boat (bpp) – vessel is moved by an engine or sail, made entirely of wood, with a closed or semi closed deck. The length is between 5 and 15 m.

The total number of vessels was about 30 small boats and 58 canoes, in Braganca District. In the Treme community, small boats (14) constituted the dominant mode of transport, while canoes (27) were dominantly used in Tamatateua (Table 4). Each canoe carried an average of four crab fishermen and the small boats carried an average of 18 crab fishermen.

Table 4: Total number of active crab fishing vessels at the respective landing points during 18 months of survey (2003 and 2004).

Local	Boat	Canoe
Bragança – Ajuruteua road	2	20
Caratateua community	8	8
Tamatateua community	6	27
Treme community	14	3
Total	30	58

In Tamatateua, canoes were landed in all local ports, while small boats frequently used the Atalaia port for landing and occasionally the Trapeval port. The Trapeval port canal is very narrow and does not allow the boats to enter easily. In Caratateua, the small boats and canoes landed in both ports with equal frequency. In Treme, the small boats and canoes used the main port; however, Aciteua port was frequented only by canoes. Treme had the highest number of small motorized boats because they were additionally used for fish capture during the fish season (June until September). Here, the dominance of motorized vessels favored that the crab fishermen traveled to more distant crab fishing areas.

The total mangrove crab catch was carried from the mangrove area to the landing points by boats, canoes or on foot (by the crab fishermen). In Treme, the dominant mode of transport was the boat, in Tamatateua, the canoe. Tamatateua showed the highest number of on foot transports (Figure 5). Surveys carried out at Taici Point did not include collecting information on the mode of transport due to the local logistics and are therefore not included.

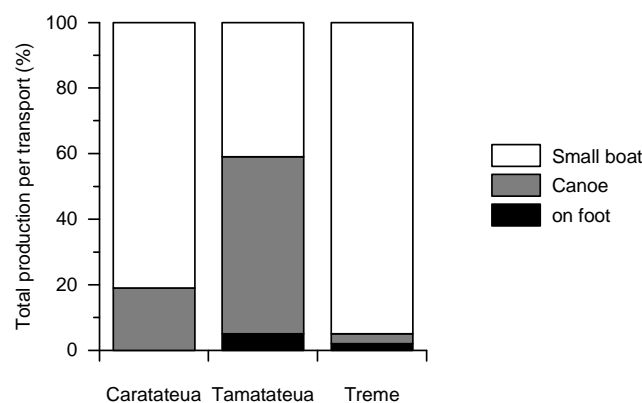


Figure 5: Types of transport (% from total) to the individual crab landing points during 18 months of survey (2003 and 2004). For landing point Taici, no data are available.

2.3.1.4 Fishing areas

The total mangrove area used by crab fishermen to capture mangrove crab was approximately 877 km² divided among: Bragança Peninsula 170 km², west zone 181 km² and east zone 526 km² (Chapter 1, Figure 1). The crab fishermen from Tamatateua exploited primarily the west zone. The boats originating in Tamatateua were able to cover all points within a 24 km radius, while the radius of the canoes was only 18 km (Figure 6). Exploitation by crab fishermen from Treme focused primarily on the east zone. Their boats were able to move in 50 km radius, while the canoes were limited to 20 km (Figure 7). The crab fishermen from Caratateua exploited primarily the peninsula. The boats and canoes originating at Caratateua were able to cover a maximum of 20 km in one trip, sufficient to reach all areas on the Bragança Peninsula's coast (Figure 8). Crab fishermen from all three communities traveling on foot explored areas close to the landing ports, including the peninsula, covering approximately 5 km.

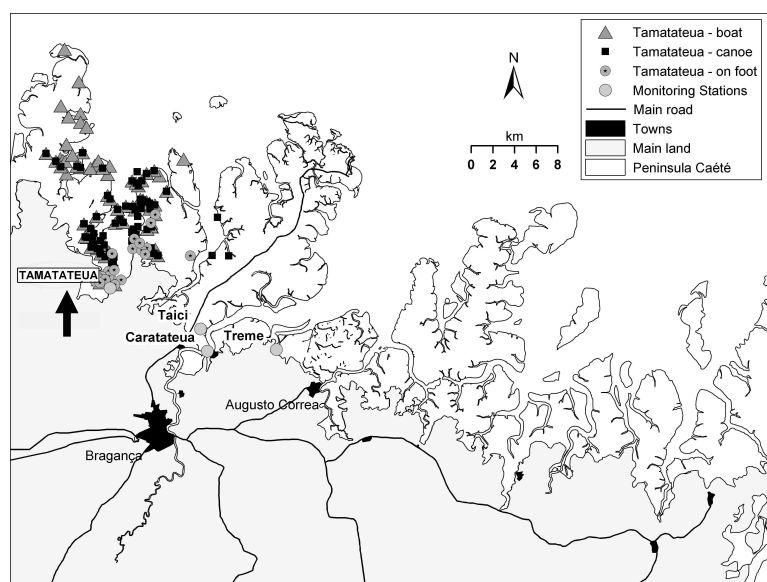


Figure 6: Catch areas and type of transport of crab fishermen from Tamatateua community. Data from 18 months, 2003 and 2004.

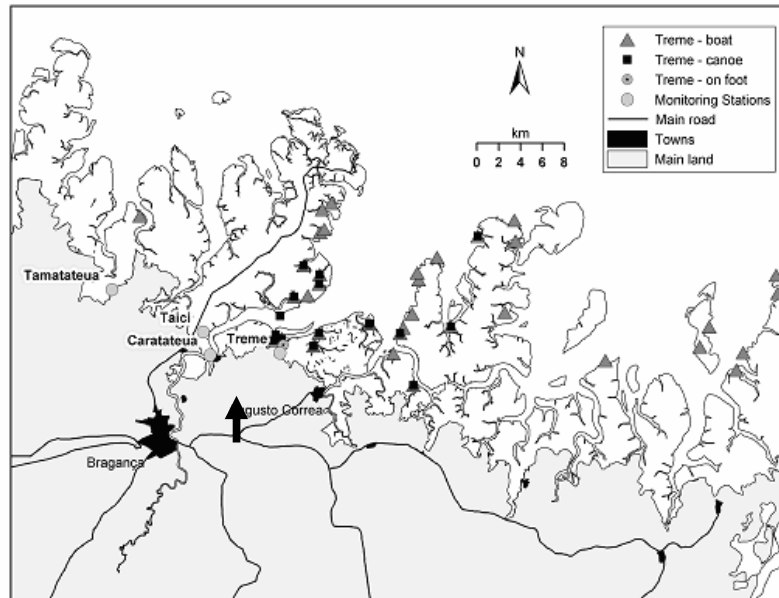


Figure 7: Catch areas and type of transport of crab fishermen from Treme community. Data from 18 months, 2003 and 2004.

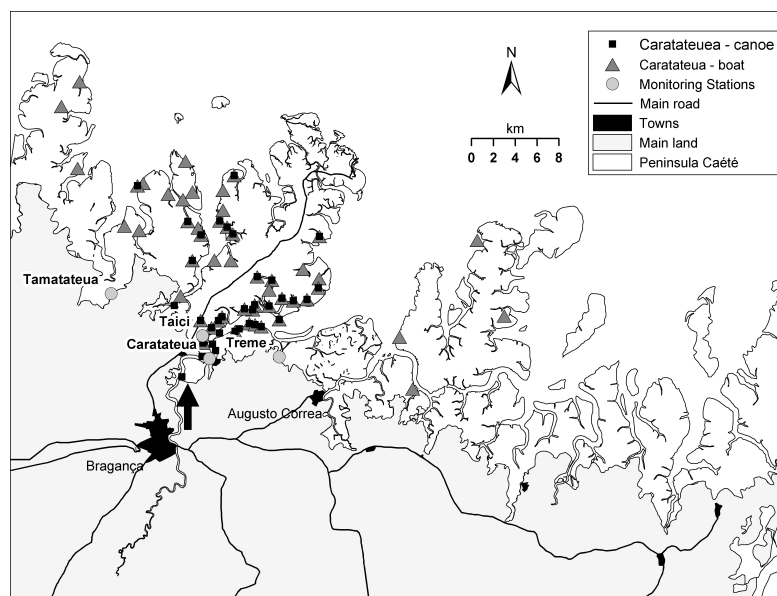


Figure 8: Catch areas and type of transport of crab fishermen from Caratateua community. Data from 18 months, 2003 and 2004.

2.3.1.5 Total capture landed in Bragança

The total capture from the Bragança peninsula was 919 t in 2003 and an additional 523 t landed from January to June in 2004. We observed a peak in January and February (108 and 107 t respectively), an accentuated fall in June (43 t) and another peak in the October (116 t) (Figure 9). In 2004 figures peaked in February with 118 t. In the period of reproduction (January to April), of both two years, we observed that the total catch landed was approximately equal, with 354 t in 2003 and 385 t in 2004. However, during May and June, when crabs retreated deeper into their burrows and were therefore harder to catch, the catch volume was different, with 88 t in 2003 and 138 t in 2004.

The total capture for the area outside of the peninsula was 940 t in 2003 and an additional 516 t from January to June in 2004. In 2003 we observed a peak in January (148 t) and another one in December (113 t). In 2004 we observed a peak of 122 t in February (Figure 9). In the February, March, May, June, July and October of 2003 and in January of 2004, the total capture from the peninsula was larger than outside of the peninsula.

The total capture of mangrove crab from the peninsula landed in Taici was 579 t in 2003, and 306 t in 2004. In 2003, the total number of mangrove crabs captured on the Bragança peninsula and landed in Caratateua, Tamatateua and Treme were 269, 4.6 and 66 t, respectively. In 2004, the total capture landed in Caratateua, Tamatateua and Treme was 179, 6.2 and 31 t, respectively (Figure 10).

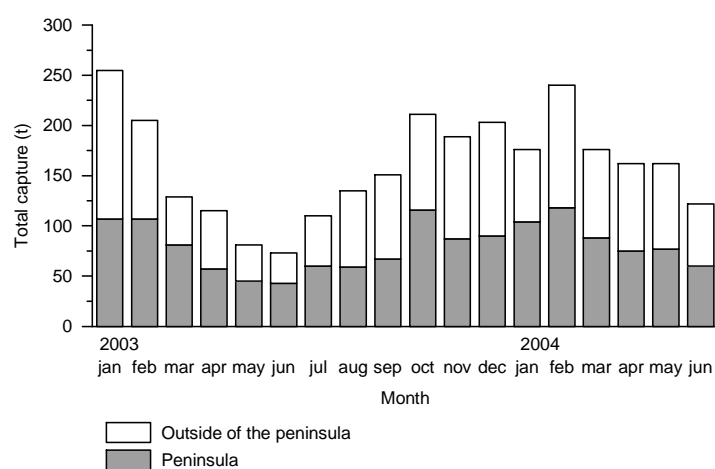


Figure 9: Monthly totals of mangrove crab capture on Bragança Peninsula and other areas (number of interviewed crab fishermen: 94328), during 18 months of survey, 2003–2004.

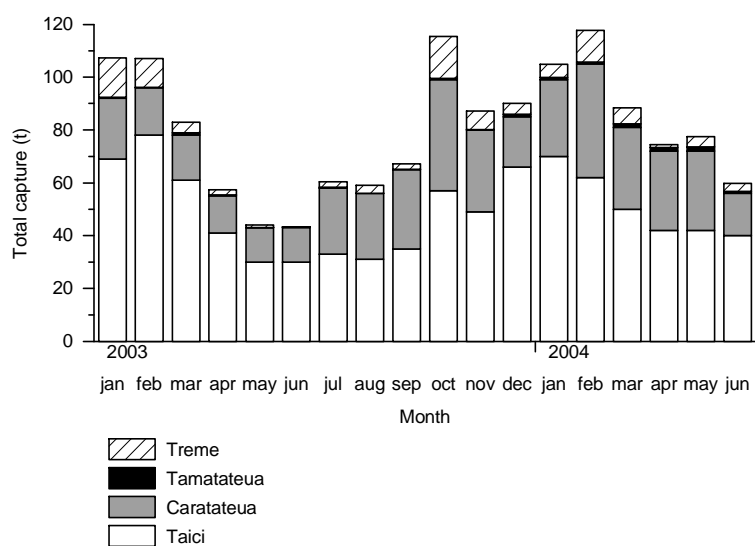


Figure 10: Monthly totals of mangrove crab capture on Bragança Peninsula by landing point (number of interviewed crab fishermen: 56176) during 18 months of survey 2003–2004.

The total capture of mangrove crab landed in Bragança District was 1859 t in 2003, with peaks in January (256 t) and October (211 t). From January to June of 2004 the total capture amounted to 1039 t, with a peak in February (240 t) (Figure 9). Comparing values from the period of reproduction (January to April) in 2003 (707 t) with the same period in 2004 (754 t), we observed a difference of approximately 50 t. However, comparing the two months (May and June) for the two years showed a very large change. Considering the total capture landed in May and June, figures doubled from 2003 (154 t) to 2004 (285 t).

2.3.1.6 Effort and Capture per unit of effort (CPUE)

The crab exploitation showed different scenarios with monthly variations over the years. For the Bragança peninsula the CPUE exceeded the fishing effort in May, June and between August and December of 2003 (Figure 11). In 2004 the CPUE exceeded the fishing effort in April, May and June. The data produced the highest CPUE values between September and November of 2003, inferring a period of higher capturability. The fishing effort showed several peaks over the year 2003, specifically in February, July and October. For 2004 a fishing effort peak was visible in January and another minor one in May (Figure 11 and Appendix 3).

The CPUE for areas outside of the Bragança peninsula produced higher values than those recorded for the Bragança peninsula in 2003 and 2004. Comparing the CPUE values for the peninsula with the higher CPUE values from areas outside of the peninsula, we find significant differences (Kruskal-Wallis; $H = 1$; g. l. = 11; $p < 0.0001$). The fishing effort outside of the Bragança peninsula peaked slightly in January, September and December of 2003 and in February of 2004 (Figure 12, 13 and Appendix 4).

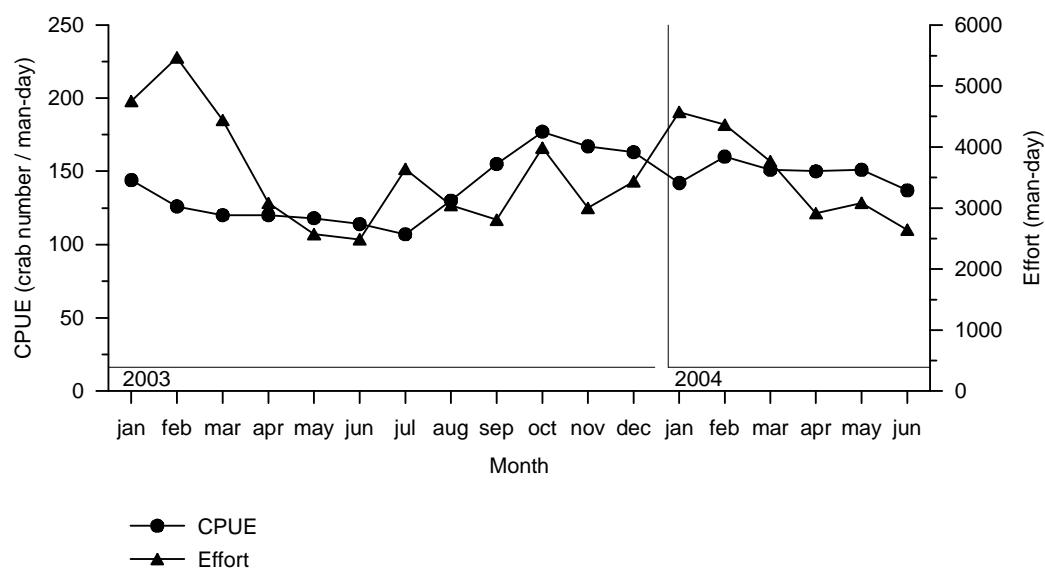


Figure 11: Catch per unit effort (CPUE) and fishing effort for Bragança Peninsula during 18 months of survey, 2003–2004.

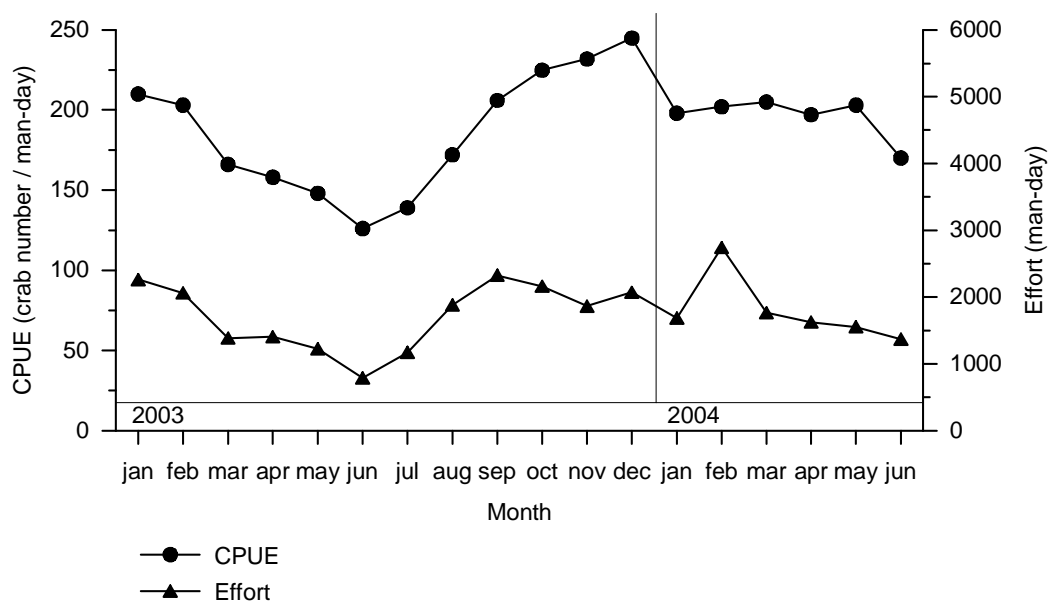


Figure 12: Catch per unit effort (CPUE) and fishing effort recorded for areas outside of the Bragança Peninsula during 18 months of survey, 2003– 2004.

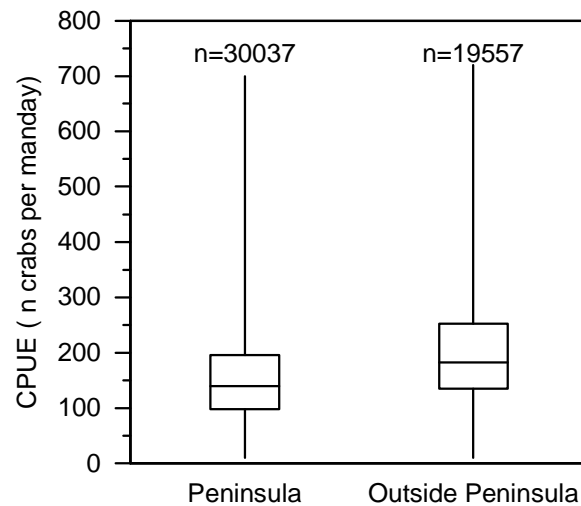


Figure 13: Comparison of catch per unit effort (CPUE) on Bragança Peninsula and outside Bragança Peninsula (mean and standard error) during 18 months of survey, 2003–2004 (Kruskal-Wallis test; $H=1$; d.f.=11; $p < 0.0001$). (n = number of the data)

2.3.2 Catch structure and life history traits

2.3.2.1 Carapace width (CW)

From March of 2003 to June of 2004 the carapace width (CW) of mangrove crabs landed in the Tamatateua and Treme ports was measured, totaling 16621 individuals. In Tamatateua and Treme, 8903 and 7718 crabs were measured, respectively. These individuals belonged to various size classes, with carapace widths ranging between 5.1 and 9.1 cm (Figure 14). Though only crabs landed at Tamatateua and Treme were used for CW measurements, the crabs had originated from all parts of the study area.

In 2003 (9 months), the CW of a total of 11776 individuals from all parts of the study area was determined. The monthly averages CW ranged between 7.1 and 7.4 cm, and the annual average (\pm SD) was 7.2 ± 0.6 cm. The largest average CW was registered in the month of November, with 7.4 ± 0.7 cm (Figure 14). Samples from 2004 (6months) totaled some 3515 measured individuals. The monthly averages CW ranged between 7.2 and 7.4 cm and the annual average CW was 7.4 ± 0.6 cm (Figure 15).

The monthly frequency distribution of carapace width for mangrove crab in 2003 and 2004, were predominantly unimodal, producing a normal distribution. The recruitment period did, therefore, not become evident in the timeframe of the study (Figures 14 and 15).

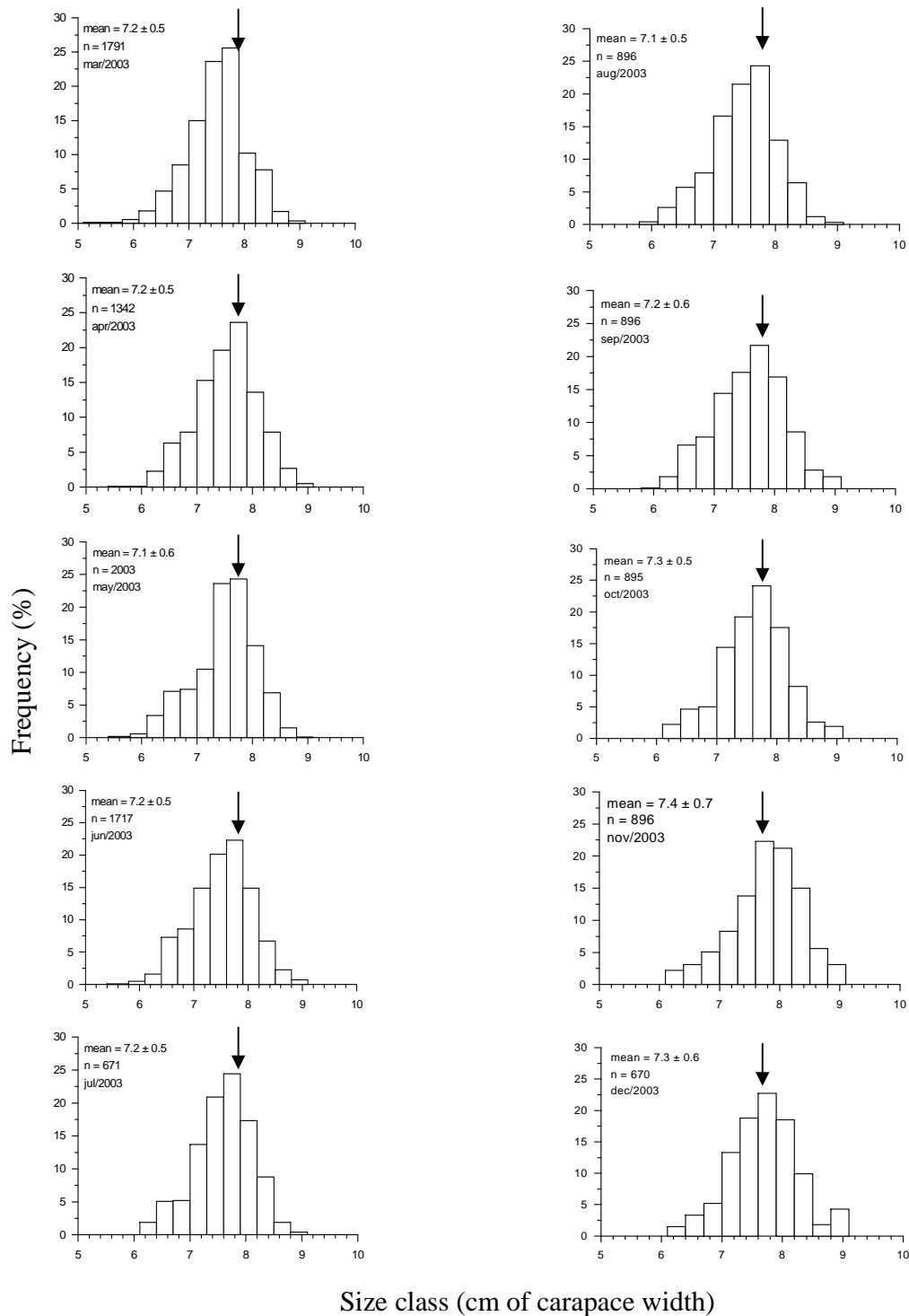


Figure 14: Size-Frequency distribution of *U. cordatus* caught in the study area between March and December of 2003.

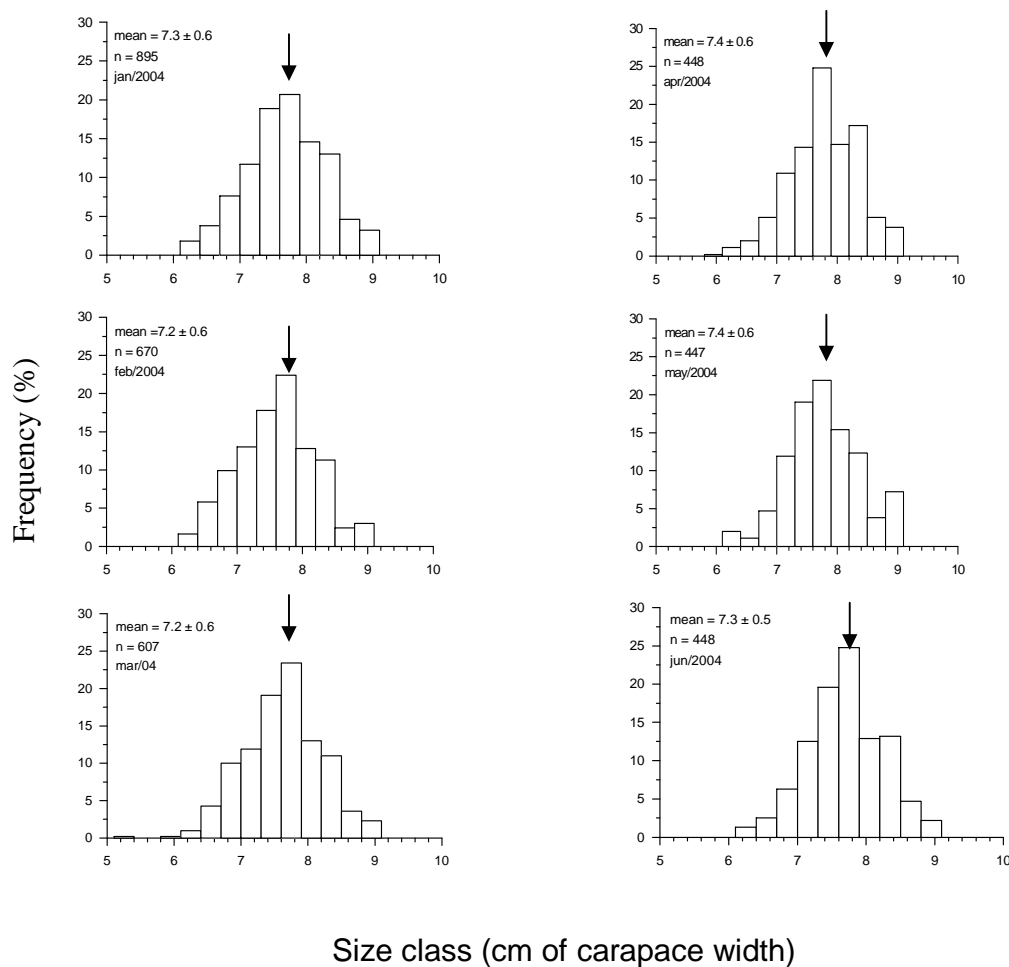


Figure 15: Size-Frequency distribution of *U. cordatus* caught in the study area between January and June of 2004.

Data from the Bragança peninsula were based on a total of 4391 carapace width measurements. During 2003 (9 months), 3236 individuals were measured, varying in sizes between 6.9 and 7.5 cm. For that year, the annual average of carapace width crabs captured on the Bragança peninsula was 7.1 ± 0.5 cm. In November the average carapace width was the highest, with 7.5 ± 0.7 cm. In 2004 (6 months), a total of 1155 individuals were measured. The averages of carapace width ranged between 6.9 to 7.5 cm, with an annual average of 7.2 ± 0.6 cm. In March and June the highest monthly averages were measured (cm) (Figure 16 and Appendix 5).

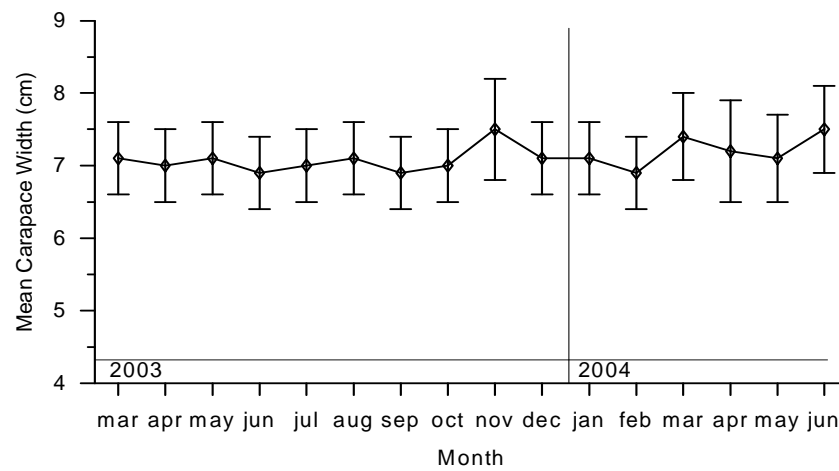


Figure 16: Monthly mean of carapace width of crabs captured on Bragança Peninsula during 16 months, 2003–2004 (number of carapace width measured = 4391). Error bars: standard deviation.

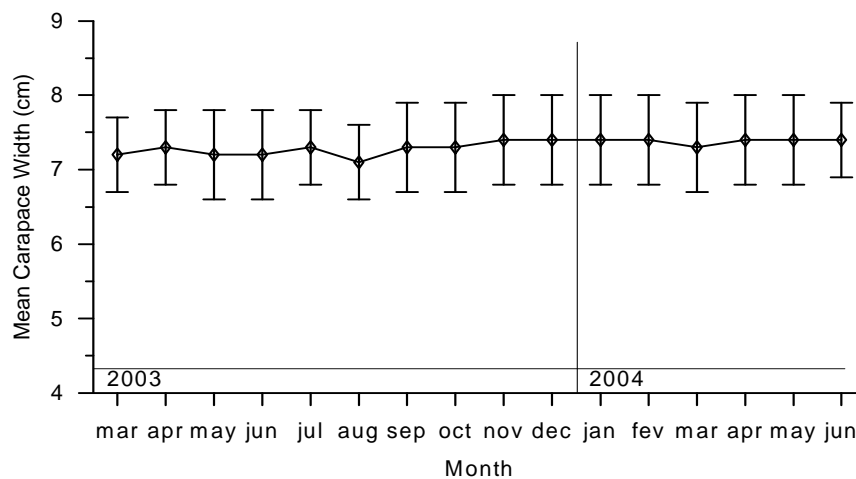


Figure 17: Monthly mean of carapace width of crabs captured outside Bragança Peninsula during 16 months, 2003–2004 (number of carapace width measured = 11506). Error bars: standard deviation.

For the areas outside of the Bragança peninsula, the annual averages of measured carapace width were 7.3 ± 0.6 cm in 2003 and 7.4 ± 0.6 in 2004. The data were based on measurements from a total of 8373 individuals in 2003 and 3133 individuals in 2004 (Figure 17 and Appendix 6).

Comparing the results for the average monthly CW from both areas showed that individuals captured on the peninsula were significantly smaller than individuals captured outside of the peninsula (t-student value = 17, $p < 0.0001$) (Figure 18). When the annual average CW from both areas are examined, the difference appears quite small (0.2 cm), but considering the large samples size (15897) this difference is significant.

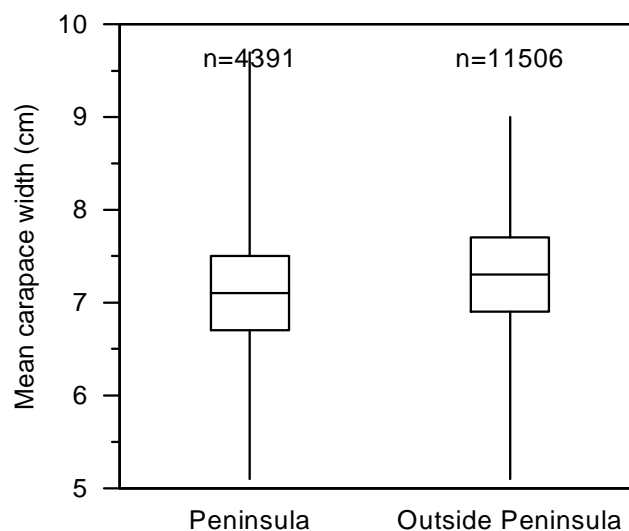


Figure 18: Box and whisker plot of carapace width of male *U. cordatus* from the whole study area. Data from 16 months, 2003–2004 (number of carapace width measured = 15897). Whiskers: ± 1.96 standard error.

When considering the measured carapace widths only from Tamatateua, the results indicated that in 2003 and 2004 the largest individuals were captured in

the eastern area (7.4 ± 0.6 cm). Crabs landed in Treme from the western areas had an average carapace width of 7.0 ± 0.5 cm in 2003. From January to June of 2004 this average was 7.2 ± 0.6 cm. In this area, individuals above the annual average were observed only in November of 2003 and in April, May and June of 2004.

2.3.2.2 Growth

The size-frequency data of carapace width (male *U. cordatus*) reorganized by the ELEFAN I program, showed positive values for size classes within modal cohorts (size class in black color) and negative values for intermodal size classes (size class blank), that do not fit the cohort being represented. The results extracted by ELEFAN I confirmed the values described in literature sources. Between January and June, one new cohort is recruited. The growth of this cohort could be observed by the evolution of the corresponding modal over time. The corresponding curve to the recruitment conscription was adjusted with the parameters K and L_{∞} listed in Table 5. The maximum value of R_n (goodness of fit) for the growth parameters was 0.54.

The best parameter combination achieved by ELEFAN I (Table 5), was that which rendered the highest values for R_n . Results produced with the Wetherall's method gave a slightly higher value for L_{∞} , whereas K values for males of *U. cordatus* was equal from all methods.

Table 5: Growth parameters L_{∞} (maximum theoretical length) K (growth rate coefficient) calculated by FISAT for *U. cordatus* males from the study area. Data from 12 months (March 2003 to February 2004).

Data Type	Method	L_{∞} (cm)	K (1/year)
Width-frequency	ELEFAN I	8.58	0.20
Width-frequency	Shepherd	8.66	0.20
Width-frequency	Wetherall	8.80	
Modal class	Bhattacharya	7.70	0.20

2.3.2.3 Mortality

For an estimate of the mortality coefficient, the following growth parameters were used: $L_{\infty} = 8.58$ cm and $K = 0.20/\text{year}$. The capture curve method by Beverton and Holt (1956) produced the highest values for total mortality (Z). All the other methods demonstrated that total mortality is very low. In the case of *U. cordatus*, the Rikhter and Efanov (1976) methods give the most accurate estimates for natural mortality (M). These methods use mass (the age in years at massive maturation) for the estimate calculation of natural mortality (Table 6).

Table 6: Mortality parameters Z (total mortality) and M (natural mortality) for *U. cordatus* males for period of 12 months (from March, 2003 to February, 2004).

Method	Authors	Z	M
Capture curve	Pauly, 1983	0.490	
length max.	Beverton and Holt, 1956	0.592	
length max.	Ssetengo and Larkin, 1973	0.410	
tmax = 12 years	Hoenig, 1984	0.436	
t 50% = 4 years	Rikhter and Efanov		0.41

The probability of capture for *U. cordatus* males calculated with FISAT showed that the size class represented in the actual catch lay between 6.8 and 7.3 cm. Individuals smaller than 6.0 cm and individuals larger than 8.0 cm were not representative of the catch.

$L_{25} = 6.8$ cm

$L_{50} = 7.1$ cm

$L_{75} = 7.3$ cm

2.3.2.4 Cohort analysis (VPA)

The results from the cohort analysis according to Jones (1984) for the data from March to February (2003 to 2004), showed that if all individuals between the sizes of 5.0 and 8.6 cm were captured, the total catch would amount to approximately 1,926 t. The estimates of Z (total mortality rate) for this size class varied between 0.40 and 0.80 per year, increasing with increasing size (carapace

width, cm). This same tendency was observed for F (fishing mortality rate), where estimates varied between 0.0 to 0.4 per year (Figure 19 and Appendix 7).

The cohort analysis (Jones, 1984) demonstrated that the size classes that contributed most to the yield (Y) were between 6.2 and 8.2 cm, reflecting the fishing mortality (F). Due to the small number of individuals with a size of 8.1 cm, the fishing mortality in this size class is highest. Biomass estimates diminished for size classes equal to or larger than 8.4 cm, due to the small number of individuals captured. The results generated by this procedure considered the situation of the population in 2003 (Figure 19 and Appendix 7).

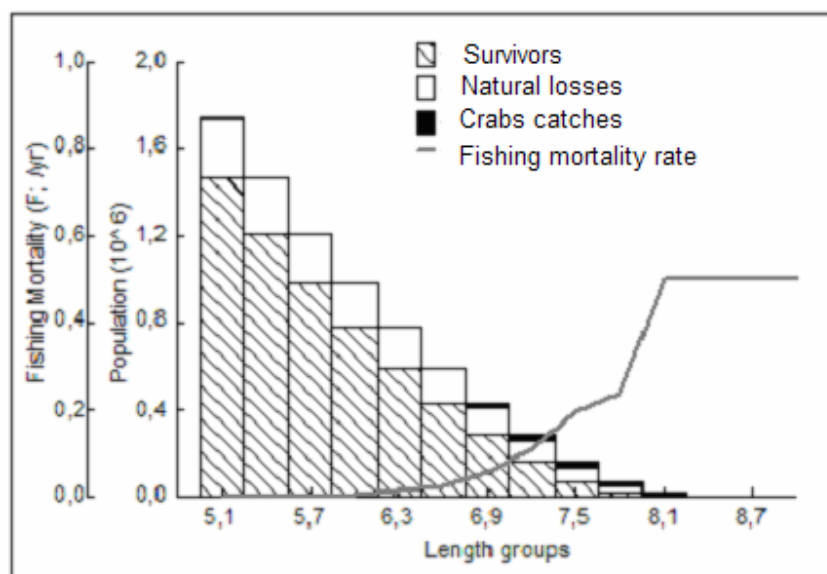


Figure 19: Cohort analysis according to Jones (1974) for *U. cordatus* males from the study area, during 12 months of sampling (March 2003 to February 2004).

2.4 Discussion

2.4.1 Mangrove crab fishing in Bragança

The mangrove crab exploitation is a very common type of fishery in the Bragança and other Brazilian mangroves. Artisanal fishermen from the coastal communities are the main exploiters of this resource. On the Bragança District coast, 1195 crab fishermen depend predominantly on mangrove crabs for sustenance, representing 6.8% of the total coastal rural population (17,567 inhabitants (FNS, 2002). Results from this study showed, that 34% (5,975 people, 1195 households) depend on the crab fishery as their main source of income considering that each crab fisherman supports an average of four family members. Glaser (2003) found that 38% (4940 people, 950 households) of the total rural population (13000 inhabitants) of Bragança District rely on the crab fishery for their main source of income. Despite the differences in the total population size estimate used in both studies, the results are very similar and show that crab fishing is of high socioeconomic importance for the region, generating jobs and income.

The monitoring carried out for this study confirmed that the crab fishermen of Bragança District captured mangrove crab using the arm and hook technique, a method that is considered not to lead to stock depletion (Ivo and Gesteira, 1999, Diele 2000 and Barbieri and Mendonça, 2004). The relative efficiency of fishing techniques used for the capture of the mangrove crab was difficult to identify. During the ecdise period of the crabs the crab fishermen used the hook more frequently in the capture. In this period the burrow is deeper, making extraction with the arm more difficult (Diele, 2000). During the other months of the year, the crab fishermen used the arm and the hook. The hook was used to assist in the capture and the transport of the *cambadas* to the landing points. It is important to

point out that crab fishermen in Bragança still do not use fishing techniques that promote stock depletion, as is the case in other states, such as Piauí, Sergipe, São Paulo, etc. The use of depleting fishing methods (covering burrow exits with nets (*redinha*), plugging burrow exits with mud to trap the crabs (*tapagem*), etc.), which have been outlawed, have caused a drastic decrease in the mangrove crab stock in those areas (Botelho *et al.*, 2000; Passos and Benedito, 2005).

From fishing techniques and the vessel characteristics used for mangrove crab exploitation, this fishery can be classified as small scale artisanal fishing according to the criteria of the FAO (2001a). The two types of vessel used in crab capture favor that fishing pressure is highest in the areas in close proximity of the communities. The non-motorized vessels do not allow exploration of more distant areas. The motorized vessel can reach areas close to the community and more distant ones. In an attempt to increase production, crab fishermen from Caratateua and Tremé using motorized vessel remain in distant mangrove areas for two or three consecutive days, without returning to the harbor.

The crab fishery is also classified as a small scale commercial fishery with a high socioeconomic value due to the many dependent families living in the coastal zone (Tiago *et al.*, 1995). Crab fishing is an activity generating income for many families, but is carried out without consideration to the sustainability of the form of resource use. The local crab fishermen gave the impression that they considered the mangrove resources as inexhaustible. This erroneous impression may be due to the considerable size of the mangrove (877 km²) exploited by these crab fishermen, and also to the large volume of daily crab landings. At the same time, they complain that the crabs that used to be captured close to the communities do not exist anymore. This statement is not entirely true, but does reflect the absence of larger crabs in those areas, though smaller ones can be found in abundance. This situation may have been caused by the high fishing pressure in those areas and by an increase of the coastal population. This development lead

to the destruction of mangrove stands to create new agricultural and living spaces (Nittrouer *et al.*, 1995, and Glaser and Grasso, 1998). With the destruction of mangroves the crabs lose their primary source of food, causing mortality or displacement.

The total recorded capture of mangrove crab by crab fishermen resident in Bragança District in 2003 was 1,859 t. This represented 1 % of the total fish catch, 17 % of the total crustacean catch and 33% of the capture of mangrove crab for Pará State. The contribution of the Bragança Peninsula to total captures in Bragança District was approximately 50%. For the same time period, the official fisheries statistic (CEPNOR/IBAMA 2004) stated that Bragança District was the region with the 4th highest crab catch in the Pará State (Figure 20). The values of total capture produced by this study were higher than those estimated by the CEPNOR/IBAMA by 900 t of *U. cordatus*. This difference can be explained, in part, by the different methodologies applied in the data collection. CEPNOR collects data biweekly and extrapolates the monthly catch from those counts. In the current study mangrove crab landings were monitored daily. The two data sets show a difference of approximately 50%, indicating that the official data for total crab capture in Pará State (CEPNOR/IBAMA) may have been grossly underestimated. CEPNOR does not specify which days of the week and which locations were used for their data collections.

In order to generate reliable fisheries statistics for the Bragança District it is important to consider that the results showed that the capture from the Bragança Peninsula constitute 50% of the total capture from the Bragança District. However, crabs landed at Taici monitoring station (Bragança-Ajuruteua road) make up only 31% of the total catch for the Bragança District and it is therefore important to monitor the main exploiters of the peninsula not passing through Taici, the Caratateua community. The days recorded at Taici monitoring station with the highest number of crab fishermen working in the mangrove area were

Friday and Saturday. In addition, the MADAM project has a historical data series on total production in Furo Grande (part of the peninsula) for eight years (Diele *et. al.*, 2005). Therefore, it can be recommended that fishery statistical data for the Bragança District should be collected at Furo Grande on Fridays and/or Saturdays and in Caratateua community. The universal recommendation for the collection of data for crustacean catch is to use some form of random sampling (Krebs, 1989). However, these recommendations are often not applied due to the lack of human and monetary resources and the selection of inappropriate sampling locations. This problem invariably leads to incorrect application of random sampling methods. These data, although preliminary, supply not only capture data, but demonstrate the necessity to have a reliable data collection mechanism in place to increase the accuracy of the estimates.

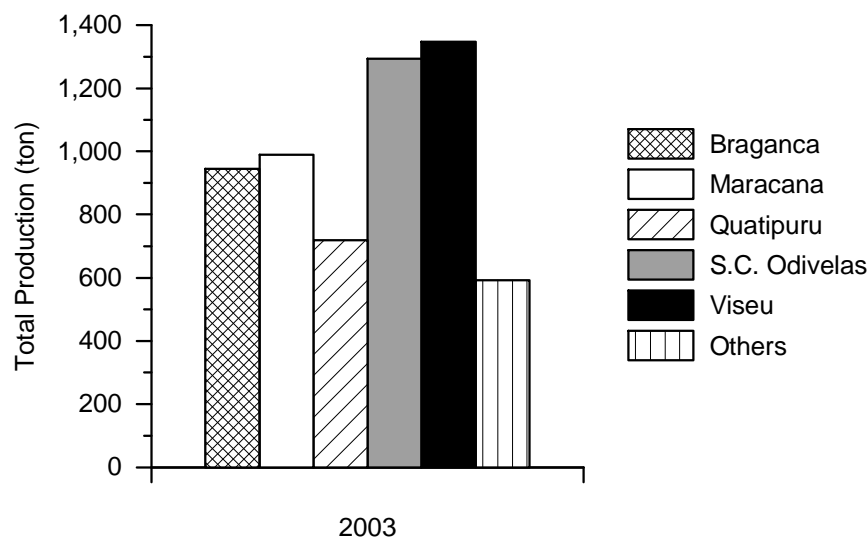


Figure 20: Total production of the mangrove crab, *Ucides cordatus*, per District, in Pará State, 2003. Source: CEPNOR/IBAMA, 2004.

The need for the improvement of fisheries statistics has already been formulated for the Southeast-South region (Haimovici, 1997), and for the North-Northeast region (IBAMA, 1994) of Brazil. The general aim was to increase the quality and reliability of the data collected and thereby improve management strategies and the quality of life for the fishermen. However, few changes could be observed over the years (Mendonça *et al.*, 2001). Statistics control, that would allow a realistic estimate of the total crab capture by the artisanal fishermen in Brazil, does not exist. This study attempted to record the total capture from Bragança District by monitoring all main points of landing. However, since not all landing points could be monitored, the total capture estimate is still too low, further increasing the numerical distance between these results and official estimates. To produce fishery statistics in the Amazônia region is very expensive and quite complicated due to the decentralized nature of landing locations (villages, towns, etc.) and fishing areas. Additionally, the varying commercialization systems make it extremely difficult to instate a systematic data control system and a standard for the measure of the fishing effort applied (Fonteles-Filho, 1977a; Aragão and Dias-Neto, 1988; Aragão, 1997). The current study estimates show that only approx. 80% of the actual crab landings were registered, due to other crab landings at points which were not monitored. However, those points had demonstrated a very low landing volume and random or sporadic landing frequencies during the period of landing point observation, preceding the start of this study. If 100% were considered, the total catch volume in Bragança District would increase to 2,231 t for 2003.

Values of total crab catch in Bragança District place this fishery among the largest of Pará State. Over the last years, crab captures have decreased in several Brazilian states, which has been seen as the first step towards the collapse of the crab stock in those areas. Presently, this decrease of capture volume is observed in the states of Rio Grande do Norte, Paraíba, Pernambuco, Alagoas, Sergipe and north of Bahia. In those states where the capture volume,

nevertheless, remained constant, the mechanisms eventually leading to overfishing were observed: the legal weight and capture size were reduced, the fishing effort increased without an increase in capture volume (Legat and Puchnick, 2004).

Although the mangrove area exploited by crab fishermen from Bragança District is extensive (877 km²), the Bragança Peninsula (170 km²) suffered the highest fishing pressure. The results for fishing effort and the resulting CPUE values showed that the fishing effort for the peninsula exceeded areas outside of the peninsula by 52%, but that the CPUE was lower by 26%. The average CPUE value calculated for the entire peninsula in 2003 (137 crabs/ man-day) was less than the CPUE (150 crabs/ man-day) that was determined for the Furo Grande (most distal part of the peninsula) in 2003 by Diele *et al.* (2005). In the same study, Diele *et al.* (2005) demonstrated a decrease of the CPUE in the years 1999 and 2000 in the Furo Grande, finally stabilizing at 150 crabs/ man-day in 2001-2003. It is possible that the decrease of the CPUE on the peninsula indicates a decrease in the *U. cordatus* stock biomass. On the other hand, it must be considered that the decrease of the CPUE is related to the fishing effort distribution. When the natural population shows aggregate distribution, the fishing effort applied in the exploitation of the fishing resources tends to concentrate in the areas where the density is higher (Rocha *et al.*, 1982 and Fonteles-Filho, 1989). In the case of the mangrove crab exploitation, the effort applied on the peninsula corresponds with the relative density of the resource and with the ease with which the crab fishermen can reach the mangrove area from the road. This may result in the reduction of the population density in highly frequented areas, forcing the crab fishermen to extend their radii of action until ultimately, their efficiency is diminished (CPUE decrease).

During the first years of exploitation of a virgin stock, high yields can be obtained, because the abundance is high. As the fishery develops and the fishing effort

grows, an increase in the total captures is observed, and in many cases, the yield too. This mechanism tends to initially mask the decrease in the stock biomass (Gulland, 1974; Hancock, 1973; Paiva, 1983; Aragão and Dias-Neto, 1988; Fonteles-Filho, 1989; Dias-Neto, 2003). In addition, this situation functions as an incentive for the ingression of new fishermen. At some critical point, a decrease in the resource abundance becomes evident (fall of the CPUE), suppressing the individual yield, although the total captures continue to grow. It is important to follow the fishery evolution so that the fishing effort can be stabilized at levels that do not produce the maximum sustainable yield (MSY), but rather approximate the maximum economic yield (MEY). Subsequently, if no other factor modifies the environment, it is possible to keep the fishery at sustainable levels for present and future generations (Aragão and Dias-Neto, 1988; Fonteles-Filho, 1989).

The results for fishing effort exerted on the peninsula and in areas outside of the peninsula can not be directly compared. For the peninsula, the total numbers of fishermen that exploit this area were monitored and so the maximal effort was known. However, for the areas outside of the peninsula, only the minimum effort is known, since the total number of fishermen could not be determined. The data only reflect the total number of Bragança District fishermen and not non- resident fishermen that must be exploring the area outside of the peninsula.

2.4.2 Catch structure and life history traits

This study considered the *U. cordatus* populations exploited on the Bragança Peninsula and outside of the peninsula as representing one stock, following the concept of Gulland (1983). The concept affirms that, for fisheries management, the definition of a stock is an operational subject. A group of organisms can be treated as a stock if the possible differences inside the group and the exchange with other groups can be ignored, without invalidating the conclusions. This

means that if no indices of separate stock units exist in the area, it is better to initiate a stock assessment effort that considers the entire distribution of the species in the area (Sparre *et al.*, 1989).

ANOVA for the mean sizes (cm CW) of captured crabs from the peninsula (7.1 ± 0.5) and from areas outside of the peninsula (7.3 ± 0.6) confirmed that the crabs captured on the peninsula were significantly smaller than those captured outside of the peninsula. The results suggest that the fishing pressure is strongest for larger individuals on the peninsula and their lower numbers compel the crab fishermen to capture smaller individuals as well. Even if the size difference shown by the data (0.2 cm) seems small, it is a warning signal that the management plan needs to reflect. However, the mean capture sizes found in this study are still higher than those in the Piauí, Paraíba, Sergipe and Rio De Janeiro states, 6.5, 4.5, 6.8 and 6.0 cm, respectively (ADEMA, 1983; Passos and Benedito, 2005; Alves *et al.*, 2005). The state of the Bragança District crab fishery is still at sustainable levels since mean capture size is bigger than the size at first and even 100% maturity ($L_{50\%}=3.51$ cm, $L_{100\%}=5.10$ cm for males) (Vale, 2003).

CW (cm) results presented by Diele (2000) and Diele *et al.*, (2005) for the Furo Grande area (part of peninsula) (7.3 ± 0.5) differ from the values found for the whole Bragança Peninsula (7.1 ± 0.5), but approximate those found outside of the peninsula (7.3 ± 0.6). It is possible that this difference is associated with the monitored landing points utilized in each study and the target market of the capture. Diele (2000) and Diele *et al.*, (2005) measured carapace width exclusively at the Furo Grande landing point, where crabs destined for the live crab market were sold to wholesalers. The crab fishermen that disembark on the road (Furo Grande landing point) are more easily surveyed than those that disembark in the communities. Additionally, crab fishermen that commercialize live crabs need to capture larger individuals to get better prices. Samples in this

study were taken from crab landings in the Caratateua and Treme communities, where all crabs are destined for the processing market and therefore captured indiscriminate of their size.

2.4.2.1 Growth

Growth is the quantitative aspect of the development process which is initiated with the first larval hatching and continues until the end of a fish's (fish, crustaceous, mollusk) life (Fonteles-Filho, 1989). Although this process can be observed and measured, growth is a most complex mechanism that represents the net product of a series of behavioral and physiological processes; initiated with food ingestion and terminating in the incorporation of organic substance by the organism, modifying its form and size (Brett, 1979).

Methods using length data proved effective in estimating growth parameters for *U. cordatus* captured in the study area. Although the crustacean physiology is very different from that of fish, the mean growth of the body seems to follow the model of von Bertalanffy (von Bertalanffy, 1934, 1938; Garcia and Le Reste, 1981). The growth of the individual crustacean differs from the von Bertalanffy model in such, that the growth curve is generated by a series of steps, each corresponding to one molt. However, cohort members molt at different times, and therefore the curve of mean growth of crustacean cohort fuses into a uniform curve (Jamieson and Bourne, 1986 and Caddy, 1988). Molting is not synchronized on the population level and a high yearly molting frequency in the juvenile phase allows the application of the von Bertalanffy growth model (Isaac, 1989). However, to analyze the data through such methods, basic biological information about the species needs to be available. For *U. cordatus* this information was provided by writings from Ivo *et al.* (1999), Diele (2000) and Vale (2003). More detailed studies on *U. cordatus* through the direct growth increment

measurement method (Diele, 2000) have been important to confirm that the indirect methods of measuring carapace width can accurately predict growth parameters.

The growth study of *U. cordatus* through the analysis of frequency distribution in the period studied, resulted in values for L_{∞} between 7.70 and 8.80 cm and K equal to 0.2/year. The L_{∞} estimates were approximately those generated by Diele (2000) for *U. cordatus* captured in the most distal part of the Bragança Peninsula (landed at Furo Grande). However, higher growth parameter values were published by Pinheiro and Fiscarelli (2001) for *U. cordatus* captured in Iguape (São Paulo) (Table 7). The differences may be related to the geographic location of the stocks, the environmental parameters, the type of samples (small or large) and/or the data collection method and analysis. Growth parameters differ not only between species but also between stocks, such that growth parameters of a determined species can have different values in different parts of its distribution (Sparre *et al.*, 1989). The samples in this study were all derived from commercial crab catch, thereby only defining the growth parameters for part of the growth curve. Due to the minor economic importance of the mangrove crab on a world-wide level, few studies on its growth have been carried out that could describe the missing parts of the growth curve.

The different methods applied to define the growth parameters, produced very similar estimates for the L_{∞} and K growth parameters. The Bhattacharya method (1967) produced a lower L_{∞} (7.70 cm) value because the sizes differences between the crabs in the capture were too small for this method and the cohorts could not be distinguished. The ELEFAN I method (Pauly and David, 1981) produced satisfactory results. This method indicated that recruitment took place in the first half of the year, during the rainy season. This result confirms the findings of Diele (2000) who, studying the reproductive cycle of this species, found that *U. cordatus* has one generation cycle per year, consisting of one

cohort initiated in the rainy season. In others regions of Brazil the reproductive cycle was also observed to ensue in the same season of the year (Mota-Alves, 1975; Alcântara-Filho, 1978; Nascimento, 1993; Santarosa-Freire, 1998).

Table 7: Growth Parameters (L_{∞} , K), indices of growth performance (ϕ'), sampling method, capture location, sampling period, data type and maximum length of the captured individuals of *U. cordatus* from three independent studies.

Parameters	Pinheiro (2001)	Diele (2000)	Present study
L_{∞} (cm)	9.0	8.75	8.58
K / year	0.28	0.19	0.2
t_0	0	0	0
ϕ'	3.12	2.68	2.69
Sample Method	Frequency Distribution	Growth increment measurement	Frequency distribution
Stock	Iguape São Paulo State	Distal Part of Bragança Peninsula, Bragança District Pará State	Bragança Coast , Bragança District Pará State
Sample period	2001	1997 -1999	2003 – 2004
Measure	CW	CW	CW
L max (cm)	9.6	7.5	9.3

The growth performance indices (ϕ') for crabs from the distal parts of the peninsula, landed at Furo Grande, and from the whole study area presented similarities that indicated that both studies were investigating the same stock

(Table 7). Sparre *et al.* (1989) affirmed that the same fish stock share the same growth and mortality parameters. An essential characteristic of the stock is that its growth and mortality parameters remain constant in its distribution area. The small difference between the values of K can be related to differences in the metabolic rate of individuals (Sparre *et al.*, 1989). The crab stock in the northern region possesses growth parameters different from those found in Sao Paulo. The \emptyset' values used to determine correlation between L_{∞} and K among the same species (Pauly, 1979) indicated that the population studied by Pinheiro and Fiscarelli (2001) is different from the Bragança stock.

2.4.2.2 Mortality

The estimates of the mortality parameters for male crabs on the basis of methods that use CW data for *U. cordatus* captured in the study area proved valuable. Estimates of losses due to mortality are difficult to define in studies on population dynamics, because the necessary data are difficult to obtain and existing methods are inexact, especially in respect to natural mortality (M). The low values of total mortality (Z) and natural mortality (M) found in this study seem reasonable, since the species is slow growing (low K) and can therefore not exhibit high total mortality (Z) (Sparre *et al.*, 1989). In the opposite scenario, the species tends to extinguish quickly (Tanaka, 1960; Holt, 1965; Saville, 1977 and Sparre *et al.*, 1989). The relationship of M/K was 2.0, confirming that the majority of the time these values are between 2.5 and 1.5 (Beverton and Holt, 1959). It is important to consider that the results from this study are valid only for the considered time period: from March of 2003 to February of 2004 and for crabs in the catch (individuals $\geq 5\text{cm}$).

The methods chosen in this study for the definition of the mortality parameters, generated values between 0.41 (Ssentego, 1973) and 0.59 /year (Beverton and

Holt, 1956) for total mortality rate (Z). These values approximate those estimated by the cohort analysis method (VPA) (between 0.40 and 0.80/year), using CW-frequency of size classes between 5.1 and 9.3 cm. This indicates that the fishing mortality (F) has a maximum value of 0.40 / year. The high estimate achieved for the natural mortality rate ($M=0.41/\text{year}$) indicates that the population is very sensitive to any increase in the fishing effort applied.

Fishing selectivity, which favors larger individuals of *U. cordatus*, is extremely important for the sustainability of the fishery. This strong selectivity of the *U. cordatus* fishery focuses on large males because of the traditional background of whole crab consumption and their commercial value (Diele *et al.* 2005). It is unclear how long this fishing strategy can maintain sustainable levels because other factors may change, such as increased fishing effort, destruction of natural habitat, etc. Changing levels of fishing effort applied can modify the age composition and the size classes in the stock, leading to rapid depletion of the local crab populations by overfishing (Paiva, 1986).

In accordance with the knowledge base produced to the present time such as: $K = 0.2$ / year, captures sizes, diminishing CPUE, it can be concluded that this species is very sensitive to intense fishing exploitation and could easily suffer a rapid depletion of the larger-sized ($CW \geq 6.5$ cm) portion of the stock. This type of overfishing occurs when the losses produced by fishing capture surpass the capacity for growth of the species. In practice, this means that the average fish sizes in the population start to diminish drastically and many small individuals start to appear in the capture.

CHAPTER 3 - Commercialization

3.1 Introduction

The land crab *Ucides cordatus* is considered one of the most important constituents of the mangrove fauna of Brazil. Over the last decades, its significance as source of income for thousands of crab collectors along the Brazilian coast has become obvious; the use of this resource has a long tradition among communities of artisanal fishermen.

Crab collecting activities have become important for an increasing part of the coastal population, creating a new socio-professional segment. This development belongs into the context of an expansion of the market since 1950, and of the extension of the road network since the 1960s. This extension led to higher dynamics in regional economy by favoring the circulation of fishery products, and facilitated the communication between the countryside and the urban centers. At that moment, small-scale fisheries became an economic alternative for family-based farmers (Furtado, 2001).

U. cordatus was sold exclusively live in coastal communities of the Bragança region up to the beginning of the 1970s. Afterwards, processed crabmeat production was initiated in Bragança and later in Caratateua and Treme (Alves, 2003). Today, crab meat is processed in Treme and Caratateua only, while in the other communities animals are sold live only. Sale of crab meat changes the post-capture processes significantly, as the crabs are dismembered still in the mangroves (Caratateua only), and are handed over to specialized crab meat extractors after the return to the landing places of some of the villages.

Due to the growing demand for *U. cordatus*, the mangrove forest became the workplace for specialized crab fishermen acting independently of the crab's life cycle. These collectors were financed by local wholesalers (“*marreteiros*”). Built up upon the existing, traditional sales channels between fishermen and wholesalers, a new commerce network emerged (Manesch, 1993). The proximity of the mangrove forest for inhabitants of coastal villages facilitated the dedication to crab fishing; thus, locals quickly entered the commercialization chain.

With the emergence of crab meat processing in the beginning of the 1970s, the commercialization chain became more complex. To be competitive at the market, division of labor was necessary (Alves, 2003). The development of specific forms of production and commercialization gave rise to a discussion of planning the use of the crabs as an economic resource in consideration of the commercialization chain. There are few studies of the commercialization chain of *U. cordatus*. Ostrensky *et al.* (1995) evaluated the technical and economic viability of cultivating *U. cordatus* on the shores of Paraná State, South Brazil.

A commercialization chain is a series of operations determined to produce and sell a certain good. In this sense, a product has to be made available at the right place, in the right moment of time and in the desired quality and quantity. The sequence of markets the product is passing through due to the activity of the different mercantile agents is called a commercialization chain.

In the definition of Brandt (1980) and Mendes (1994), commercialization includes all activities necessary to satisfy the needs and demands of the market, as planning of production capacities, organization of the transfer of the ownership of goods, making means of physical distribution available, and the facilitation of all processes of the market. For the organization of the use of fishery resources, a

link between the use of economic instruments and the re-definition of production models is indispensable.

The aim of this study is to describe the commercialization chain of *U. cordatus*, to identify the units of commercialization, commercial transactions, the mercantile agents involved, the channels of commercialization, the costs, the marketing margins, markup and the target markets involved in the local crab commercialization.

3.1.1 Commercial theory

This chapter develops some of the common theoretical references used in the study of commerce. To better understand the individual components, a thorough review of the main commercialization chains and channels, marketing margin and markup, is necessary.

3.1.1.1 Commercialization chains

A commercialization chain is an articulated productive set of integrated activities, consisting of consecutive interaction between the market, technology and capital (money) (Chevalier, 1978 and Selmani, 1992). According to Monfort (1983), the concept of the commercialization chain refers to the idea that goods or services are a product of a succession of operations effected by diverse linked units as a whole. The succession of operations in the chain starts with extraction and raw materials and terminates with the successful distribution of the product.

According to Selmani (1992), the "Bureau of Information and Economic Forecast", (BIPE) is an enterprise operating on the basis of commercialization

chain analysis by offering a succession of technical training periods for production and distribution aspects, ultimately responding to the market and final demand.

The "French Association of Normalization" (AFNOR) (1987) presents a different definition of the commercialization chain, considering it a chain of modifications that transform raw materials into products of economic value. This chain commences with the exploitation of the raw material in its natural environment and ends with its return to nature, passing through the production circuit of consumption, recovery and elimination.

According to the "Study on the commercialization chains of the Agribusiness *Paranaense*" (Secretariat of Agriculture and Supply - SEAB, 1999), a commercialization chain is understood to consist of a set of economic agents and their relationships, established to meet the needs of the consumers for one determined product that has had a phase of agricultural or agriforestry production. Included in the chain are all those supplies and human resources needed and used prior to the product entering the market and the industrial, technical and institutional (legal, normative, regulatory, etc.) apparatus necessary once the product has entered the market.

Burnquist (1994) emphasize that the study of commercialization chains is composed of two basic aspects:

- 1) Identification of the individual units (products, itineraries, agents, operation)
- 2) The analysis of the regulating mechanisms (structure and functioning of the markets, intervention of the State, planning).

Castro (1998) presents the following concepts:

1. Agricultural business: consists of a set of operations of production, processing, storage, and the distribution and commercialization of agricultural/agriforestry supplies and products, including support services (technical assistance, credit, etc.);

2. Commercialization chains: are a set of interactive components, including agricultural/agriforestry services and productive systems, industries of processing and transformation, distribution and commercialization, with inclusion of the final consumers of the products and the by-products of the chain.

The same authors illustrate a typical agricultural or agriforestry chain, with its main components and flows. The most common components are:

1 - The consumer market composed of the individuals that consume the product (and pay for it);

2 - The net of wholesalers and retailers;

3 - The industry of processing and/or transformation of the raw materials;

4 - Properties of agriculture or agriforestry, with their diverse production systems;

5 - Suppliers of the farming supplies needed for the primary production: seasonings, herbi-and pesticides, machines, implements and other services.

The authors explicitly state that these components are embedded in

1. An institutional environment (laws, norms, regulating institutions, etc.); and

2. An organizational environment (government institutions, credit, etc.),

that each exerts influence on the components of the chain.

Zylbersztajn *et al.*, (1992) indicates that the concerns and objectives of agribusiness studies center on the coordination aspects of the chains. The coordination aspect gains especially high importance in those chains exposed to international competition and to the increasing pressures of the consumers, to which these chains must continuously adapt. The concept concedes to the notion that an actor of basic importance exists: the final consumer of the product generated by the chain. However, the idea is extended to include all actors along the chain who contribute to or intervene in some way with the termination of the chain. Thus, each technical independent action along the chain is executed by a specialized agent who will deal directly with one or more of the other agents in the chain. The final objective is the production of a good or service for the "final teacher", the consumer, placed at the tip of consumption.

Consequently, the production chain's main objective is to supply the final consumer with the product in the exact quality and amount that is compatible with the demand, and at competitive prices. Castro (1998) considers the influence of the final consumer on the individual components of the chain to be very strong and therefore stresses the importance of knowing the demands of the consumer market in order to guarantee the sustainability of the commercialization chain.

3.1.1.2 Commercialization Channels

For Kotler (1998), the commercialization channel is responsible for linking the producer and the consumer by bridging the main gaps of time, place and ownership that separate the goods and services from those that desire to use them. The commercialization channel or marketing channel is the way by which a free market system transfers the ownership of goods and services. The

arrangements of the chains are dynamic, since companies constantly look for ways to improve their selective positioning. An improvement in the structure of the chain can always result in a real competitive advantage.

3.1.1.3 Marketing margin

For Mendes (1994), the marketing margin of a commercialization is produced by the price differences between the various levels of the commercialization system. Ultimately, the total marketing margin (MT) is the difference between the final price paid by the consumer and the value received by the producer. For the individual mercantile agent this is usually expressed as the percent revenue received by him from the total marketing margin through his own action in the market (sale with price increase from previous commercialization level). For the present work, this instrument is an important component for dealing with the crab commercialization chain, since the marketing margin allows a quantification of the readjustments of the price along the chain and shows the relative gains by the actors at each level of commercialization.

3.1.1.4 Markup

In addition to the marketing margin (MT), the markup (MK) during crab commercialization is used to show the individual gain of the various agents as a function of the readjustments of prices when the product is sold to the next level of commercialization. The markup (MK) differs from the marketing margin (MT) in that it does not consider the total price increase from producer to consumer for the calculation, but is limited to quantifying the gain for an individual achieved by selling to the next level. The markup is usually expressed as the percent that the

price increase represents in terms of the price paid by the agent to acquire the product.

In this study, analysis of the commercialization chains is used to delineate the flow of products and processes, characterizing the linkage in the market structure, and the segmentation of the links into producers, wholesalers and retailers. The theoretical commercialization chains concepts serve as a basis for this analysis, so that the internal and external factors of the productive activities in the crab fishery and its channels of distribution can be exposed.

The theoretical recital of this work focuses mainly on definitions by Reis (1997) who described the general flow of the commercialization system based on the products of family agriculture. According to Hoffman (1987) commercialization is appraised as a set of operations or functions carried out in the process of taking the goods and services from the primary producer to the final consumer. Since the commercialization chain of *U. cordatus* has been little studied, this study also incorporates concepts by Mendes (1994), in an attempt to characterize the commercialization chain more thoroughly.

3.2 Methodology

During a 12-month-period (January–December 2003), commercialization prices for *U. cordatus* landed in Bragança District were recorded to serve as a base for the present work. These data were collected concurrently with the crab fishery statistics (see chapter 2 – methodology). Data were extracted from the following sources: 1) Data collection in the field consists of (a) landing data and (b) interviews with mercantile agents and 2) Data collection for summary of crab legislation in Brazil.

3.2.1 Data collection in the field:

a) Landings

The field data consisted of information on prices obtained by crab fishermen as primary members of the commercialization chain. Data were collected at the Tamatateua, Caratateua, Treme control points and on Taici Bridge (chapter 2 – 2.3.1.3). The following aspects of the field data questionnaire are analyzed:

- Sell to the market or to the boss
- Commercial unit utilized – *cambada*, basket, net, sack, etc
- Price per unit

b) Interviews with mercantile agents

The interviews served to obtain data for the subsequent levels of the commercialization chain. Interviews included information about:

- Daily purchasing/sales prices from wholesalers that buy live crab in Taici and Tamatateua and sell outside of Bragança District– price per *cambada*. The same two wholesalers were interviewed weekly.
- Daily purchasing/sales prices from wholesalers that buy live crab in Taici and Tamatateua and sell on Bragança Market – price per *cambada* . Ten wholesalers were interviewed weekly.
- Price per *cambada* paid by consumers on Bragança Market. Bi-weekly price checks on the market were conducted.
- Daily purchasing/sales prices of processed crabmeat from wholesalers– price per Kilogram (Kg). 20 wholesalers were interviewed weekly.
- Daily purchasing/sales prices of processed crab meat in supermarkets and shops in Belém - price per Kg. Ten mercantile agents (small business owners) and three mercantile agents (supermarkets) were interviewed monthly.

Data Analysis

For the description of the commercialization system of *U. cordatus*, the model by Reis (1997) and Hoffman (1987) was adapted to describe situations where small quantities of agricultural goods are sold to wholesale buyers who thereby acquire larger stocks of the respective product to be then sold to retailers. These retailers, in turn, supply a number of shops selling the products to the consumer. Important characteristics for the description of the commercialization process are:

- Units used in crab commerce and commercial transactions.
- Mercantile agents (Reis, 1997; Hoffman, 1987):
 1. wholesalers (buy directly from the producers or other wholesaler)
 2. retailers (sell directly to the consumers in small quantities)
 3. consumers

- The commercialization chain (sequence of markets the product passes through), classified by its complexity and extension according to Reis (1997).
- Seasonal changes in crabs supply and its effect on crab prices
- Commercialization costs used to define the net income: gross income (GI) minus costs (C) (Carvalho *et al.*, 1996; Carvalho *et al.*, 2000; Hoffman, 1987; Pedrosa and Carvalho, 2000; Shang and Merola, 1987; Carvalho *et al.*, 2003)

$$\text{Net income (NI)} = \text{Gross income (GI)} - \text{Costs (C)}$$

- The overall marketing margin is simply the difference between the producer price and the final consumer price, also expressed as percent (Table 8).
- The markup represents the amount added to a cost to arrive at a selling price. It is the price spread between two levels in the market divided by the selling price, also expressed as a percent (Table 9).
- Marketing margin is gross profit expressed as a percentage of the final selling price. Markup is gross profit expressed as a percentage of cost.

Table 8: Calculation of absolute and relative commercialization margins (Mendes, 1994).

	Marketing Margin	Percentage Marketing Margin
Total marketing margin	$MT = P_r - P_p$	$100 \frac{MT}{P_r}$
Wholesaler marketing margin	$MW = P_w - P_p$	$100 \frac{MW}{P_r}$
Retailer marketing margin	$MR = P_p - P_w$	$100 \frac{MR}{P_r}$

P_r = sales price retailer (for sale to the consumer)

P_w = sales price/wholesaler

P_p = sales price/producer (crab fishermen)

Table 9: Calculation of absolute and relative markup (Mendes, 1994).

	Markup	Percentage Markup
Total markup	$MKT = P_r - P_p$	$100 \times \frac{MKT}{P_p}$
Wholesaler markup	$MKW = P_w - P_p$	$100 \times \frac{MKW}{P_p}$
Retailer markup	$MKR = P_r - P_w$	$100 \times \frac{MKR}{P_w}$
P_r = sales price retailer (for sale to the consumer) P_w = sales price/wholesaler P_p = sales price/producer (crab fishermen)		

3.2.2 Statistical Analysis

Differences between daily prices at the first commercialization level in the live crab commercialization chain were tested using analysis of variance (ANOVA). Due to non-normal distribution the Kruskal-Wallis post hoc test was applied.

3.2.3 Data collection for summary of crab commerce legislation in Brazil

The information was collected from various sources including: books, scientific articles, dissertations, law journals, fishery institutes and information published on the internet.

3.3 Results

3.3.1 Systems of crab commercialization

The crabs captured in the study area and landed in Bragança District entered the market via the crab fishermen in two forms: a) *in natura* – live crab and b) processed - pulp and chelae crabmeat. For a better discussion of the two commercialization pathways, they have been divided accordingly: a) the live crab commercialization system and b) processed crab commercialization system.

3.3.1.1 Live crab commercialization system

Data for the live crab commercialization system came exclusively from landings at Taici and Tamatateua, though crabs were captured in all parts of the study area.

3.3.1.1.1 Units used in live crab commerce

The most frequently used unit in the landings of live crabs for commerce was the *cambada* (Figure 21). The sack and basket units (indeterminate number of crabs) had appeared in the Taici and Tamatateua communities during the months of reproduction (*andada*), and were used to transport crabs meant for the fishermen's own consumption. Due to the highly perishable nature of live crabs, the fishermen sold their crabs to the purchaser immediately after landing. In Tamatateua community 99%, and in Taici 94% (Ajuruteua-Bragança road), of the crab landings were sold in *cambadas*.

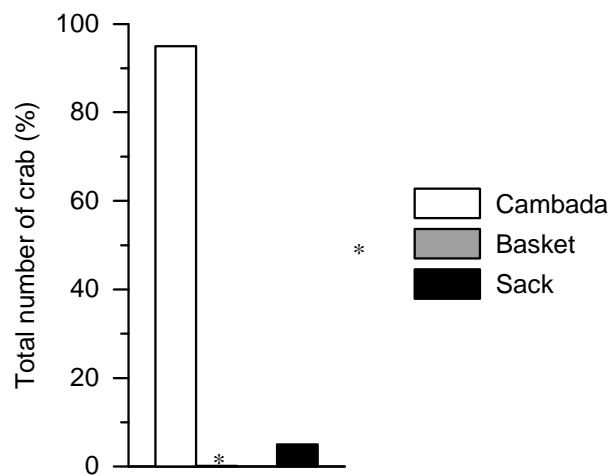


Figure 21: Percentile use of commercialization units in the landing (in Taici and Tamatateua) and commercialization of live crab on the Bragança District coast, in 2003 (n = 57360 data). Value for “Basket” < 0.1%.

3.3.1.1.2 Commercialization type

The common forms of live crab commercialization were to the market (MV), to the boss (PV) and to others (somebody at the landing point, to the neighbor, etc) (Figure 22). Overall, live crabs were sold predominantly to the market (MV). However, the results show that 73% of the commercializations in Taici were carried out via the market (MV) and while this was only the case in 25% of the commercializations in Tamatateua. In only 21% of the commercializations in Taici and 72% in Tamatateua, the boss (PV) was used (Figure 23).

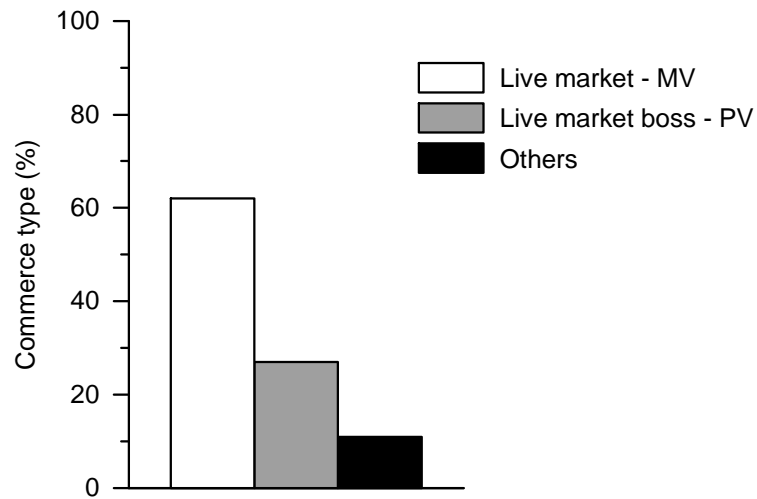


Figure 22: Percentage of commerce types for live crab in Bragança District (total landings from Taici and Tamatateua), 2003.

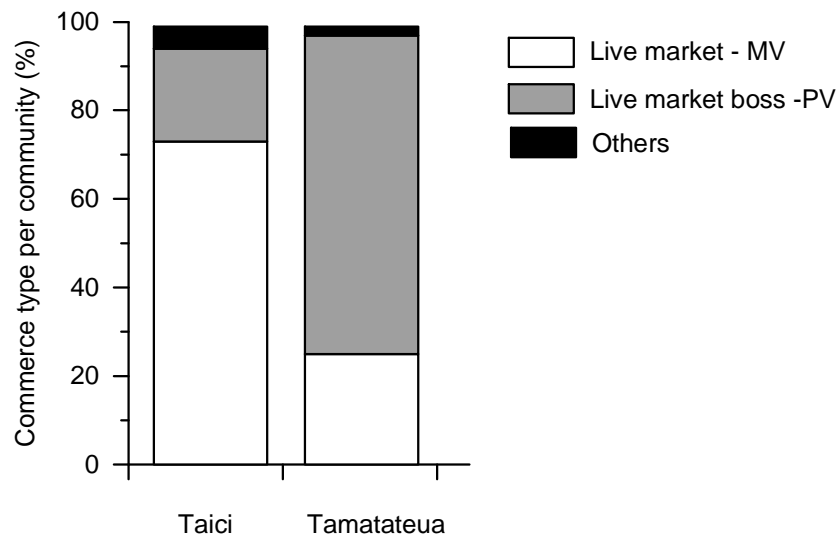


Figure 23: Percentage of commerce types for live crab by community for Bragança District, 2003.

3.3.1.1.3 Characterization of the mercantile agents involved in the commercialization

In the commercialization chain of live crab a mercantile agent, known in the communities as *marreteiro*, was identified. In this context, anyone who bought crabs at the landing points for resale was referred to as *marreteiro*. In addition, some of them functioned as a boss to several fishermen or owned boats used by the fishermen. These agents were characterized as wholesalers/retailers in this study, because they bought live crabs from the crab fishermen and sold them directly to the consumers. The wholesalers/retailers were either inhabitants of the communities themselves, or came from outside of the community.

Besides the wholesaler/retailer, the main mercantile agents were the producers (crab fishermen) and the consumers of live crab. A crab fisherman was defined as a professional whose main income is generated by capturing and selling crabs (See chapter 2: Fishery Statistics 2.3.1.1). The producers sold live crab either to their boss, or to the wholesaler/retailer or directly to the consumer. Approximately 55% of the producers had established relationships of dependence with the wholesaler/retailer. Consumers bought crab from producers and/or wholesalers/retailers.

From this point on, crab fishermen will be referred to exclusively as producers.

3.3.1.1.4 Commercialization channels

With the identification of the mercantile agents involved, the commercializations channels open to the producer were uncovered. Three live crab commercialization channels were identified (Figure 24):

Commercialization channel 1 - producers to consumer – least frequent with an occurrence of 2% in Taici and 1% in Tamatateua. The producers sold their production directly to the consumer in the landing point, or had taken the bus to the Bragança market to sell it there.

Commercialization channel 2 – producers to wholesaler/retailer to consumer - occurred 74% in Taici and 26% in Tamatateua. The producers sold their production to the wholesalers/retailers at the landing point or on the Braganca market. The wholesalers/retailers, in turn, sold to the consumers on Braganca-Ajuruteua road, on the Bragança market and/or on the Ajuruteua beach.

Commercialization channel 3 – producers to wholesaler/retailer (boss) to consumer - occurred 21% in Taici and 72% in Tamatateua. The wholesaler/retailer, boss of the producers, buys the entire production. The wholesaler/retailer moves ~10% of the production to Bragança market, while the remaining ~90% are dispersed to Belém market and other Districts.

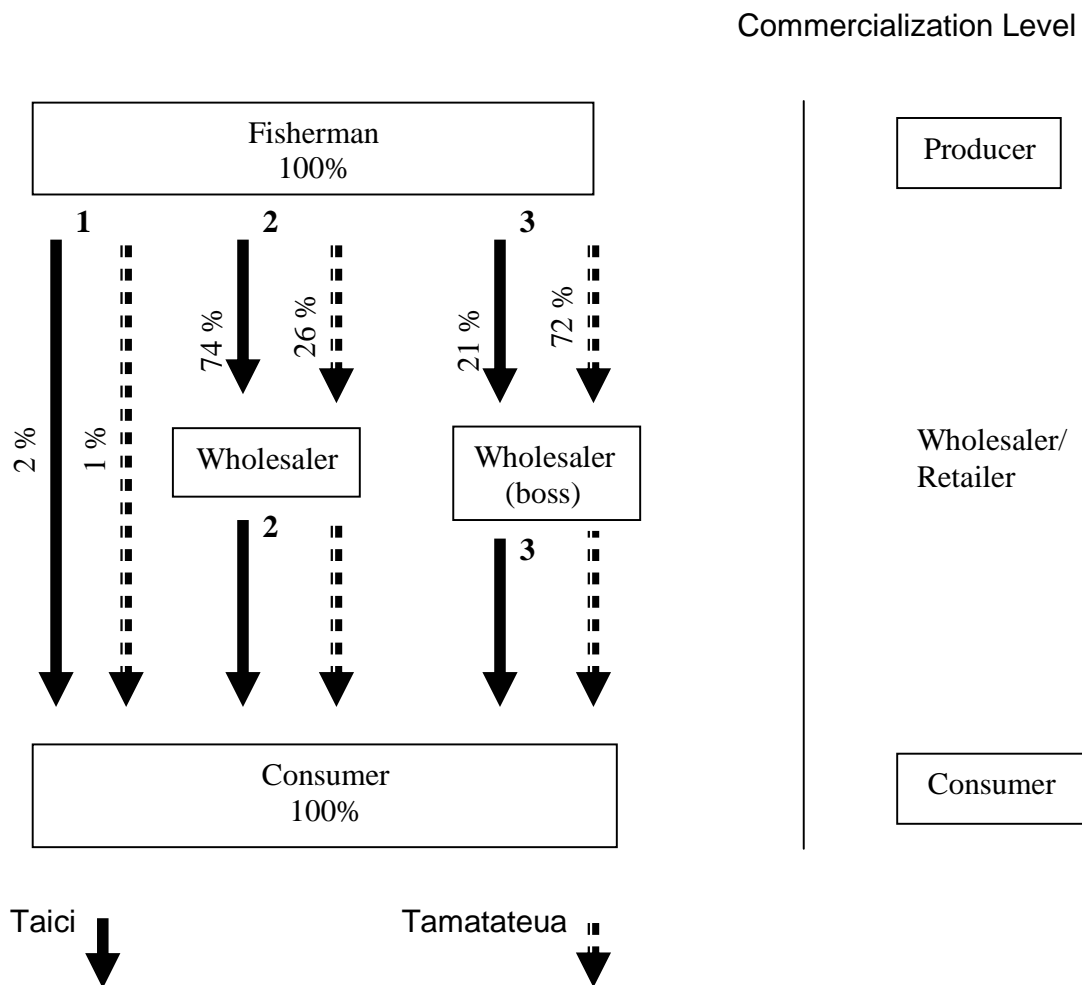


Figure 24: Commercialization channels of live crab *cambadas*, for Bragança District, 2003.

3.3.1.1.5 Crab supply

In the study area, the mangrove crab fishery was active throughout the entire year. The crab supply conformed to the seasonality of the species: a) the period of reproduction (andada) from December to April, b) the period of molting

(ecdise) from May to August and c) the main harvest period from September to November.

The months with the largest crab supply were January to April and September to December. In April, the crab supply decreased sharply, reaching its minimum in June and July (Figure 25). The total crab landings in 2003 were 935 t (6,051,292 crabs) in the Taici and Tamatateua community, representing approximately 432,235 *cambadas*, which generated a sum of R\$ 994,141.00 at an annual average market price of R\$ 2.30 ± 0.3.

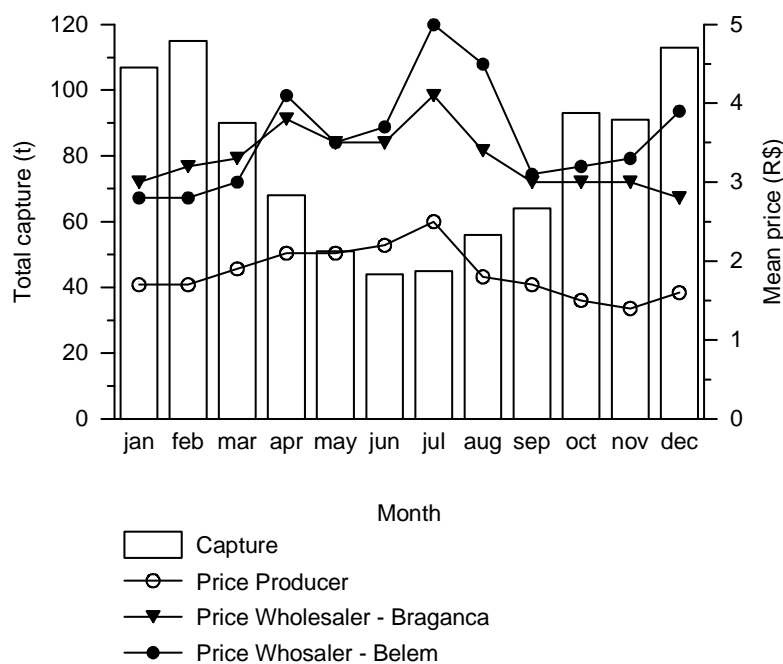


Figure 25: Total crab capture and mean sales prices of live crab *cambadas* per month, landing points Tamatateua and Taici 2003.

In February, *cambadas* in Taici sold for as low as R\$ 1.00, while in the Bragança market the cost was still R\$ 3.00. In July, crab capture was more difficult and the supply low, while the demand remained constant, causing prices to surge to R\$

2.50 per *cambada*. At the end of August, the crab harvest was initiated and the prices started to decrease due to increasing supply. In December, the prices on the Belém market had risen compared to November; however, the same trend was not observed for the Bragança market. (Figure 25).

The results show that producer and wholesaler prices for live crab had an increasing tendency until the end of July and decreased thereafter (Figure 25). At the wholesaler/retailer level, the prices on the Belém market were higher than those on the Bragança market from April to December. From January to March, this trend was reversed.

3.3.1.1.6 Price fluctuation

Crab landings were recorded on all weekdays from Monday to Sunday at monitoring points Taici and Tamatateua. For live crabs, sales prices varied depending on crab supply and demand as functions of seasonality and number of wholesalers at the landing point. However, more intense fishing activities were observed at Taici and Tamatateua on Friday and Saturday (see chapter “Fisheries Statistics”). Significant differences among prices of single weekdays are listed in Table 10. (Kruskal-Wallis ANOVA; $H(6, N = 34030) = 1216.530$; $p < 0.0001$).

Table 10: Number of interviews, mean and standard deviation of sales prices for live crab *cambadas* for each day of the week, in 2003 (in Brazilian R\$; $n = 34030$ interviews).

Day of the week	Interviews	Price (R\$) Mean \pm SD
Monday	3067	2.3 \pm 0.3
Tuesday	5368	2.1 \pm 0.3
Wednesday	4646	2.2 \pm 0.3
Thursday	3588	2.2 \pm 0.4
Friday	8472	2.0 \pm 0.3
Saturday	8231	2.1 \pm 0.3
Sunday	658	2.8 \pm 1.1

3.3.1.1.7 Production costs

The capture and sales of live crab involves certain production costs at the various levels of commercialization (Appendix 8). The presented scenarios are: 1) Producer with boss, 2) Producer without boss, 3) Wholesaler/retailer who sold at the Bragança market and 4) Wholesaler/retailer who sold at the Belém market (some were boss of crab fishermen).

1) Producer with boss

The average monthly production of the producers varied between 128 and 240 *cambadas* per person. The crab fishermen worked an average (\pm SD) of 4 ± 1 days per week. The average monthly sales price of one *cambada* varied between R\$ 1.40 and R\$ 2.50. The total production cost involved, was R\$ 1.35 per day, and remained constant throughout the year 2003.

Cost (C) = R\$ 0.10 cotton thread to fix the glove
R\$ 1.00 tobacco
R\$ 0.15 match box
R\$ 0.10 tobacco paper

Total cost R\$ 1.35

(Tobacco smoke is used as an insect repellent in the case of the crab fishermen and has therefore been included in the costs)

Considering the accrued costs per month, the net income of a producer with a boss was a minimum of R\$ 260.00 and a maximum of R\$ 362.00, in June and December, respectively (Appendix 9).

2) Producer without boss

The average monthly production of the producer without a boss also varied between 128 the 240 *cambadas*, and the crab fishermen worked an average (\pm SD) of 4 ± 1 days per week. The average monthly sales price of the *cambada* varied between R\$ 1.80 and R\$ 3.00. The total production cost involved, was R\$ 2.85 per day and remained constant throughout the year 2003.

Cost (C) = R\$ 0.10 cotton thread to fix the glove
R\$ 1.00 tobacco
R\$ 0.15 match box
R\$ 0.10 tobacco paper
R\$ 0.50 plastic thread to make *cambada* (atilho)
R\$ 1.00 bus ticket (two ways)

Total cost R\$ 2.85

Considering the accrued costs per month, the net income of a producer without a boss was a minimum of R\$ 274.00 and a maximum of R\$ 434.00, in June and December, respectively (Appendix 9).

3) Wholesalers/retailers who sold at the Bragança market

Wholesalers/retailers bought a monthly average of 304 to 464 *cambadas* from the producers without boss. The average monthly price of the *cambada* was between R\$ 1.80 and R\$ 3.00, and the sales price varied between R\$ 2.80 and R\$ 4.10.

The costs involved for the wholesaler/retailer were limited to the acquisition of a bus ticket and the cost of the *cambadas*. The daily costs produced to the local wholesaler from buying the crabs, varied with the amount of crab that the individual wholesaler purchased. When the wholesaler/retailer bought more, the total cost increased, even though the cost per unit may have decreased. The costs varied between R\$ 547.00 in October and R\$ 1.104,00 in July. The highest net income was generated in August with R\$ 603.00 (Appendix 11). The crab loss due to mortality on the Bragança market was minimal, for crabs were sold on the same day of capture. The Bragança market is quite close to the mangrove area and the crabs do not suffer much from transport to the market. If crabs could not be sold on the day of capture, but had to be kept till the next day, their mortality was approximately 2%, thus generating additional costs to the wholesaler/retailer. When the crab mortality increased, the net income diminished.

4) Wholesalers/retailers who sold on Belém market

Wholesalers/retailers bought an average of 2280 to 4048 *cambadas* per month. The price ranged between R\$ 1.40 and R\$ 2.50 over the year 2003 (Appendix 12). Typically, these wholesalers/retailers were the bosses of some crab fishermen and could therefore purchase to a lower price. They worked on two days of the week, Friday and Saturday. The average monthly sales price varied between R\$ 2.80 and R\$ 5.00.

The commercialization costs of these agents were higher than those of other wholesalers/retailers. They bought atilho (plastic thread to make *cambada*) to distribute to the crab fishermen, rented a truck, contracted people who sold live crab on the Belém market and had losses due to crab mortality during the trip. The average monthly costs were at R\$ 7,389.00 in November and R\$ 10,663.00 in June (Appendix 12).

Costs were reduced through the payments made by people using the truck for transport to the market (price fixed per *cambada* transported). The maximum net income was R\$ 5,917.00 in December. Additional costs, such as: flat tire, payment of police bribes and other expenses that reduce the profit, were not considered for the calculation of total net income.

Comparison of the average monthly net income for the 4 scenarios showed that wholesalers/retailers who commercialized on Belém market had the highest net income (Figure 26). On the other hand, the producers had the highest profit /*cambada* (Figure 27).

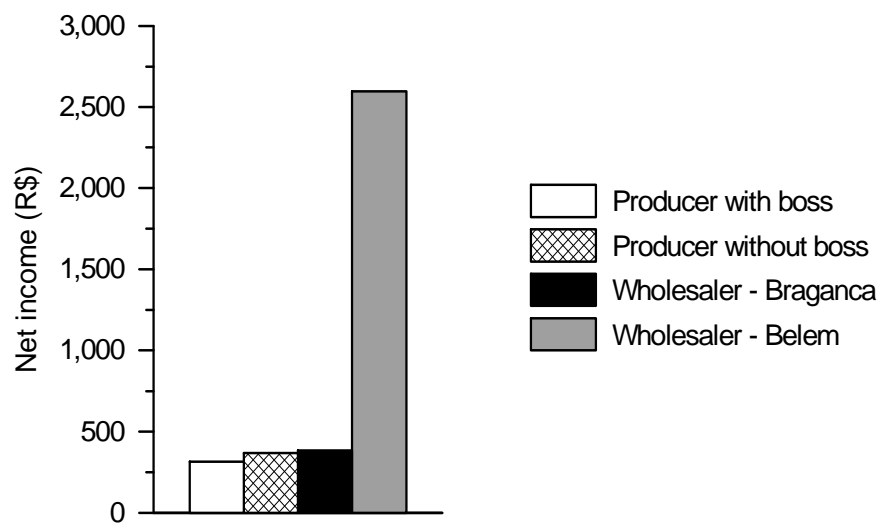


Figure 26: Mean monthly net income of mercantile agents involved in live crab commercialization, Bragança District, 2003.

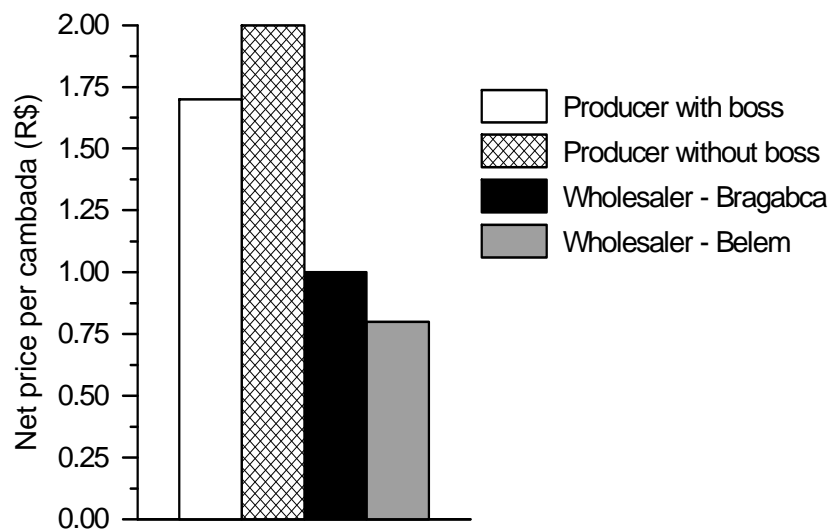


Figure 27: Mean monthly profit per *cambada* of mercantile agents involved in live crab commercialization, Bragança District, 2003.

3.3.1.1.8 Marketing margins of commercialization

3.3.1.1.8.1 Marketing margins in Bragança

The marketing margin of commercialization for the producers in Bragança District without a boss fluctuated throughout the year (Figure 28). Producers achieved the largest marketing margin in March (76%) and the least in October (61%) and November (60%). The marketing margin of the producers was equal to or higher than 60%, throughout the entire year. The wholesalers/retailers achieved the highest marketing margin in November (41%) and the lowest in March (24%).

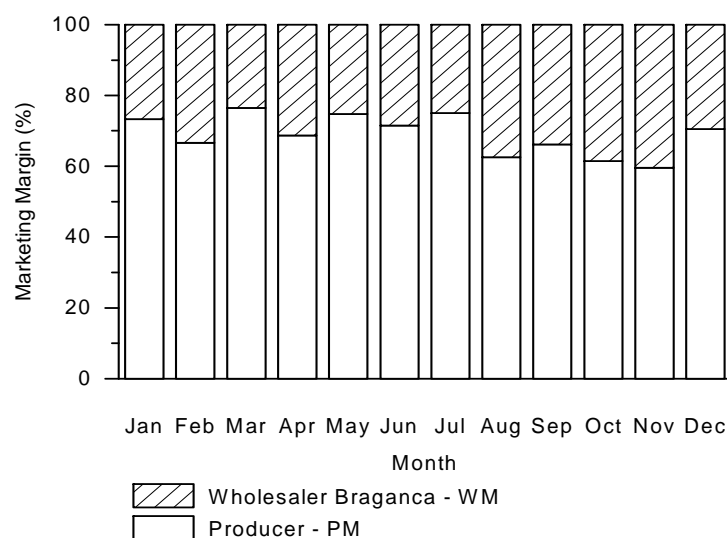


Figure 28: Relative marketing margin (%) of producers without boss and wholesalers from the commercialization of live crab in Bragança District, 2003.

3.3.1.1.8.2 Marketing margins in Belém

The highest marketing margin for producer in Belém with a boss was observed in March (65%), and the lowest in December (40%). In April and from June to December the marketing margin for the producers was placed equal to or below 60% (Figure 29).

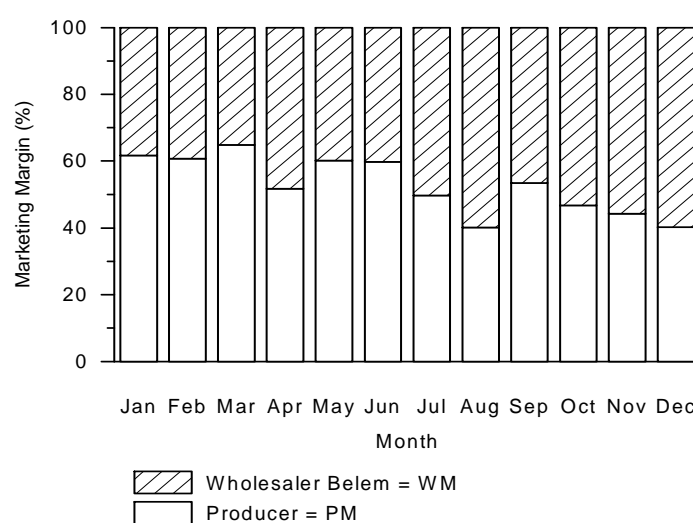


Figure 29: Relative marketing margin (%) for producers with boss and wholesalers from the commercialization of live crab in Belém, 2003. Crabs captured by producers with boss are exclusively sold in Belém and other cities outside of Bragança district.

3.3.1.1.9 Markup

Another factor in the commercialization chain is the markup that occurs during the transfer of goods from one level of commercialization to the next. The total markup (MKT) during the commercialization of live crab raised the end prices by 32% to 67% on the Bragança market and by 58% to 150% on the Belém market.

The final consumer in Bragança paid approximately 32% more for one *cambada* in March, than the sale price of the producer, and 67% more in October/November. The consumer who bought live crab in Belém paid 58% more in August and 150% more in August of the initial producer price (Figure 30 and Appendix 13).

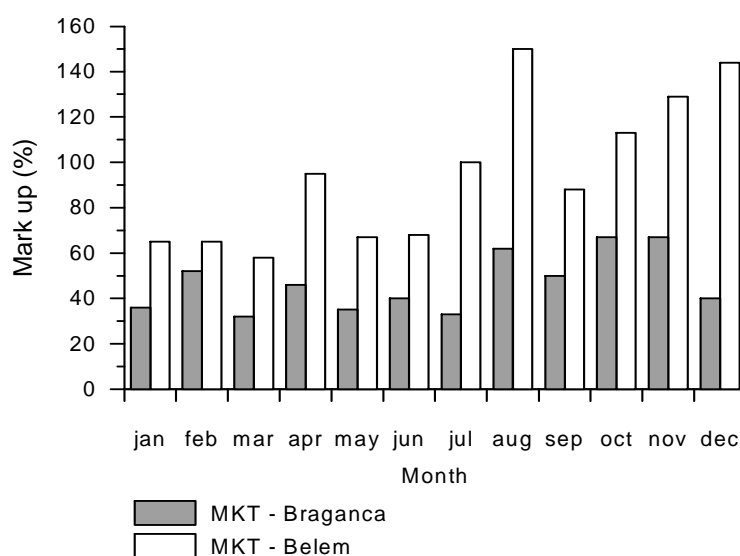


Figure 30: Percentage of total markup (MKT) during the commercialization of live crab sold on markets of Bragança and Belém, 2003.

3.3.1.1.10 Target Market

The live crabs that were landed and sold at diverse points in Bragança District, supplied not only the local market, but the state market as well. The local market was restricted to consumers buying crabs on the markets and in restaurants. The crabs were taken to the Bragança market by bicycle, bus or truck. The Para State market included Districts such as: Mãe do Rio, Aurora do Pará, Ipixuna,

Paragominas, etc. (Figure 31), the live crab being brought there by truck. Two trucks handled the export of live crab from Bragança District to markets in other districts. One truck collected the crabs landed in Tamatateua and the other those from Taici. On Fridays, the two trucks worked separately, making two routes, while one transport truck with one route was sufficient on Saturdays:

a) Route 1 - Markets of others Districts: Capanema, Santa Maria, São Miguel, Mãe do Rio, Aurora do Pará, Ipixuna, Paragominas (South of Pará state) (Figure 31). When crabs in sufficient numbers were loaded and the prices were high, the wholesalers/retailers drove as far as the Imperatriz District, in the Maranhão state. The truck covered approximately 300 km.

b) Route 2 – Additional markets of others Districts: São Domingos do Capim and Abaetetuba (Figure 32).

c) Route 3 - Belém markets (Figure 33): On Saturdays, a truck collected crabs in Tamatateua, and brought the production as far as Acarajó Village. After that, the other truck coming from Taici, took the entire production of the two trucks to the Belém markets. A distance of 200 Km is covered by this route. Some times the truck goes to Mosqueiro to sell *cambadas*.



Figure 31: Route 1: transport of live crab from Bragança District to markets of other districts, 2003.



Figure 32: Route 2: transport of live crab from Bragança District to markets of other districts, 2003.



Figure 33: Route 3: transport of live crab from Bragança District to markets of other districts, 2003.

3.3.1.2 Processed crab commercialization system

Data for the processed crab commercialization system came exclusively from landings at Caratateua and Treme, though crabs were captured in all parts of the study area.

3.3.1.2.1 Units used in processed crab commerce

The unit used in the commercialization of processed crabmeat was kilogram (Kg). The crab fishermen from Caratateua who captured crabs, detached the crab carapace in the mangroves and stored the useable remaining parts in plastic bags for transport. Upon disembarkation, the capture was transferred to a basket (\pm 40 broken crabs) and weighed. In contrast, in Treme, the whole live crabs were collected in nets (crab numbers between 50 and 300) and were taken directly to landing sites for processing (Figure 34). The whole crabs were then processed into pulp and *chela* crabmeat. The baskets were sometimes used as commercialization units, specifically in May and June when total capture of the crab fishermen was around 1 or 2 baskets. Cooled processed crabmeat could be stored for up to 8 days prior to commercialization.

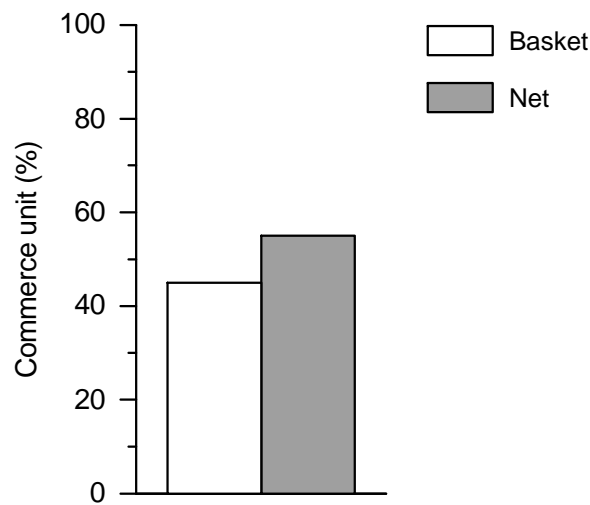


Figure 34: Percentile use of commercialization units in the landing and commercialization of processed crab on the Bragança District coast, in 2003. (n = 36924).

3.3.1.2.2 Commercialization type

Crabs in the commercialization chain in Caratateua and Treme, were processed by individual families into pulp and *chela* crabmeat. In these two communities the commercialization type used was the sale of processed crabmeat to the boss (PC) (Figure 35 and 36). The fishermen paid the boat owners for their transport into the mangroves with part of their capture. The payment was made with crabs and not directly with money.

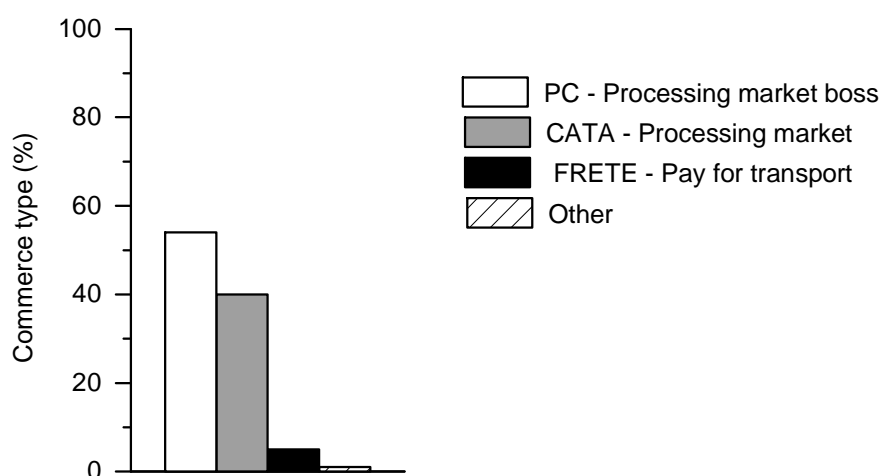


Figure 35: Percentage of commerce types for processed crab, at Bragança District, 2003.

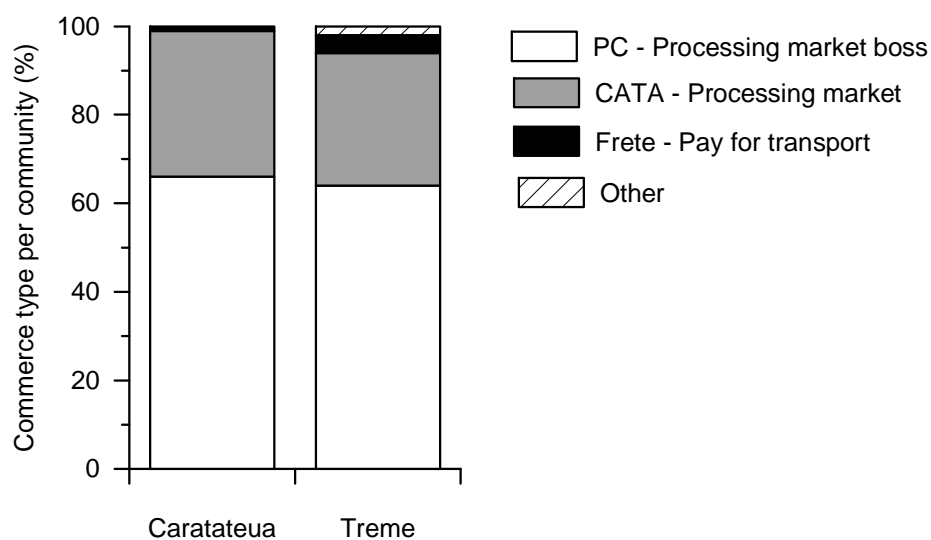


Figure 36: Percentage of commerce types for processed crab by community for Bragança District, 2003.

3.3.1.2.3 Characterization of the mercantile agents involved in the commercialization

In the commercialization of processed crabmeat, five mercantile agents were identified: the producer, the consumer, the middleman, wholesaler and retailer. For each type of mercantile agent distinguishing characteristics were identified. Producers were defined as professionals whose main income is generated by capturing and selling crabs (See chapter 2: Fishery Statistics 2.3.1.1). They represent the first level of the commercialization chain. They sold the processed crab to: the boss, the middleman, the wholesalers and directly to the consumers. Approximately 70% of the producers had an established relationship of dependency with the wholesalers (known in the community as boss).

The middlemen purchased crabs from the producers and sold them to the wholesalers. They were inhabitants of the communities that had established commercialization ties with wholesalers. They organized the departure of boats into the mangroves and bought the capture from the producers. These middlemen worked for the wholesalers, and instead of receiving wages, they resold the production with a markup. This agent was only found in the commercialization chain of processed crabmeat.

Wholesalers purchased processed crabmeat from producers, middlemen and other wholesalers. They sold processed crabmeat to other wholesalers and retailers. The wholesalers lived within or outside of the communities, were owners of boats and were privileged to a certain financial autonomy. The wholesalers living outside of the communities had a bigger purchasing power than the local wholesalers. They financed most of the commercialization, buying processed crab from producers without a boss, from middlemen and other wholesalers. They sold processed crabmeat to the supermarkets, fish stores and

restaurants in Bragança, Belém and other districts of Pará State. Some also sold processed crabmeat to other States.

The retailers sold small amounts of processed crabmeat directly to the consumers. They were proprietors of stores, supermarkets and restaurants.

3.3.1.2.4 Commercialization channels

Identification of the mercantile agents involved, uncovered the channels of commercialization open to the producer. Four processed crabmeat commercialization channels were identified (Figure 36):

Commercialization channel 1 - producers → consumer - least frequent, with an occurrence of 0.05% in Caratateua and 0.04% in Treme. The producers sold their production to the tourists in the community or to people from the community who wanted crabmeat for home consumption or for special occasions.

Commercialization channel 2 – producers → local wholesalers → retailers → consumer – occurrence of 20% in Caratateua and 21% in Treme. This channel was used by local wholesalers who had bought the processed crabmeat from the producers (with boss). They also bought from producers without a boss. They sold to wholesalers outside of the communities or directly to the retailers in Belém.

Commercialization channel 3 – producers → wholesalers → retailers → consumers – occurrence of 33% in Caratateua and 34% in Treme. The producers without a boss were the main users of this channel. The processed crabmeat from the families of the crab fishermen was sold to the wholesaler offering to pay the highest price.

Commercialization channel 4 – producers → middlemen → wholesalers outside of the communities → retailers → consumers – occurrence of 47% in Caratateua and 45% in Treme. The middlemen and wholesalers outside of the communities were the main users of this channel. The processed crabmeat from the families of the crab fishermen was sold to the middlemen who resold to the wholesalers. The wholesalers sold to the retailers who resold to the consumer.

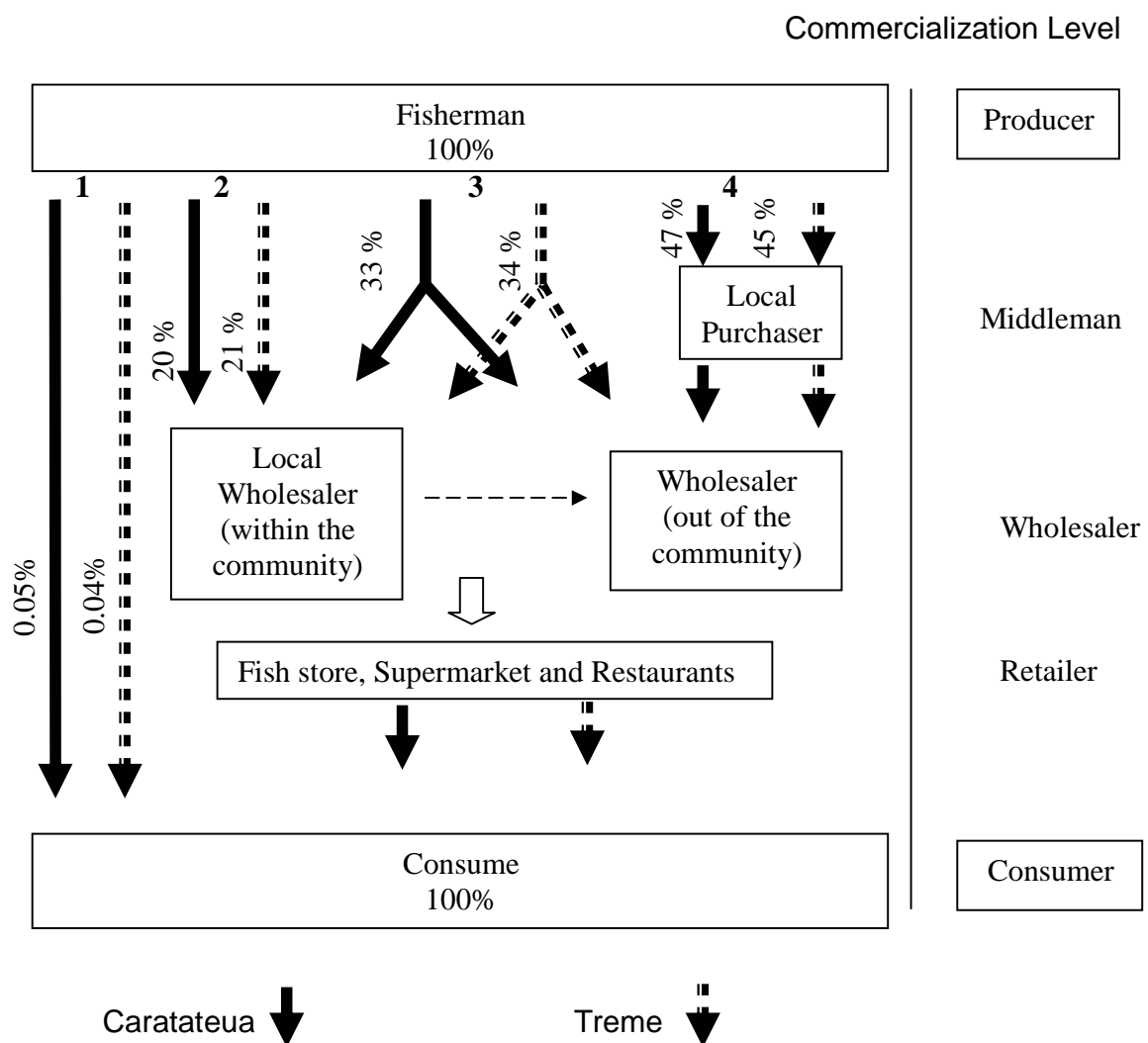


Figure 37: Commercialization channels of processed crab in kilogram, for Bragança District, 2003.

3.3.1.2.5 Crab supply

The month with the highest crab supply was January, with decreasing supply from January to May and an increase from May to October. In March, the crab supply decreased sharply, reaching its minimum in May and June (Figure 38). The total crab landings in 2003 in the Caratateua and Treme communities, amounted to 924 t (5.970.277 units) (see chapter 2). This entire production was processed and commercialized as pulp and *chela* crabmeat (Kg). Considering the annual average price (\pm SD), of R\$ 3.80 \pm 0.2 for pulp crabmeat and 4.50 R\$ \pm 0.1 for *chela* crabmeat, this commercialization generated an approximate sum of R\$ 878,484.00, for the communities.

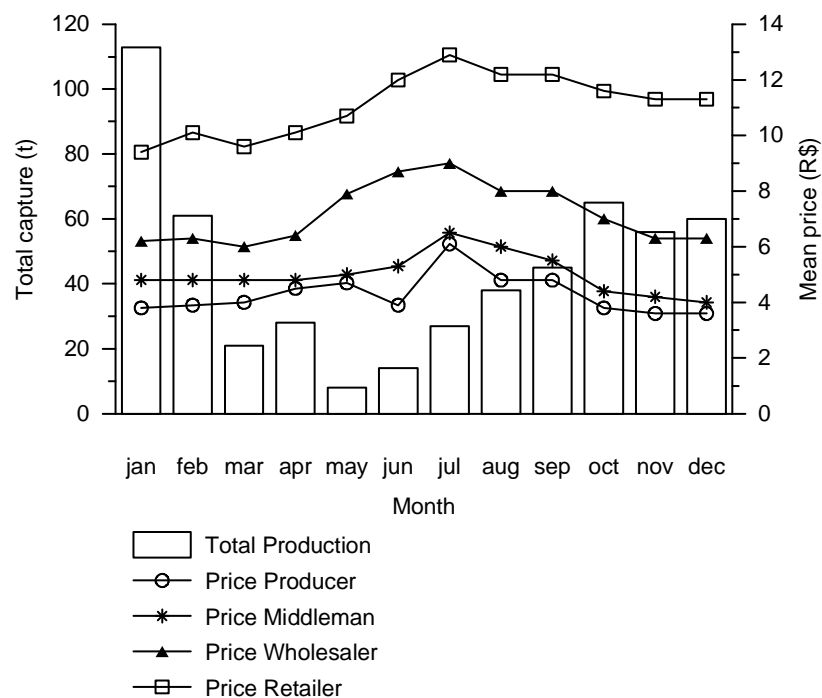


Figure 38: Total crabs capture and mean sales prices of pulp crabmeat in kilogram per month, landing points Caratateua and Treme 2003.

For all mercantile agents that commercialized pulp crabmeat, the mean prices showed an increasing tendency from April to July and decreased thereafter. The producers had a production low in June due to the difficulty of capturing crabs in this month (Figure 38). The mean prices for the producers and middlemen leveled from January to March. Prices rose until reaching the maximum value in July, with R\$ 6.10 for the producer and R\$ 6.50 for the middleman. Thereafter, prices decreased, reaching the minimum value in December, with R\$ 3.60 for the producer and R\$ 4.00 for the middleman (Figure 38). The difference of the commercialization price between the producer and the middleman was very small.

Comparing the price differences in the commercialization of the pulp crabmeat, between wholesaler and retailer, the same increasing trend is observed from January to July, and a reduction from August the December. Prices for retailers leveled off from October to December (Figure 38).

In the commercialization of *chela* crabmeat, the prices for the producer, the middlemen and the wholesalers tended to grow slightly between January and July, after which they decreased until December. For retailer the prices had an increasing tendency and leveling off from July to December (Figure 39).

The processed *chela* crabmeat is considered a noble product. This is evident in that this product has an elevated price, which did not decrease on the level of the retailer when production increased. The demand for this product is very high and the supply is scarce.

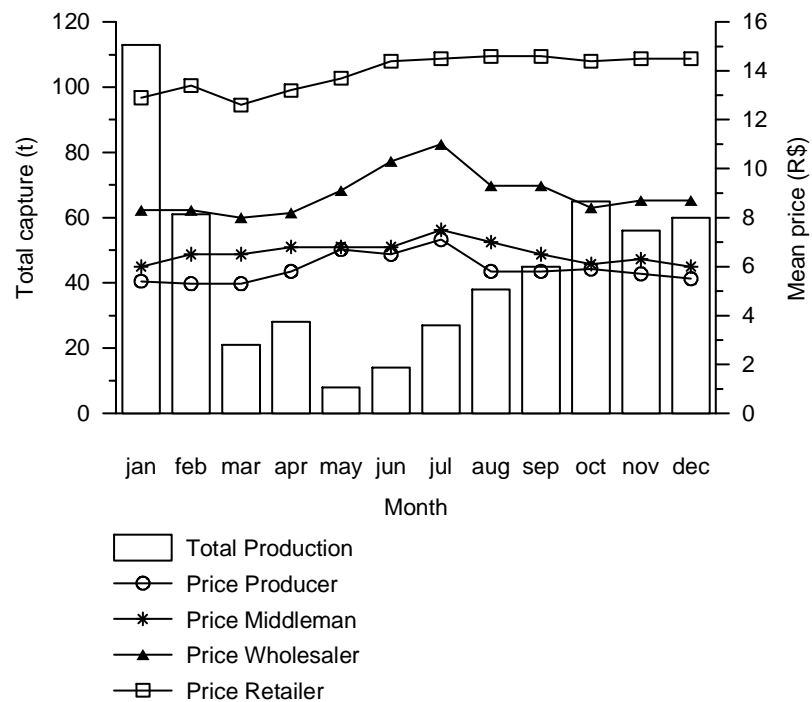


Figure 39: Total crabs capture and mean sales prices of chelae crabmeat in kilogram per month, landing points Caratateua and Treme 2003.

3.3.1.2.6 Price fluctuation

Crab landings were registered every day, from Monday to Sunday, in Caratateua and Treme. For the processed crabmeat, the price fluctuation was a function of seasonal supply and demand of the crab. The processed crabmeat can be cooled or frozen, enabling the seller to wait for a better market price at which to sell his product.

3.3.1.2.7 Production costs

The capture and sales of processed crabmeat involves certain production costs at the various levels of commercialization. To obtain 1 kg of pulp crabmeat and 300 g *chela*e crabmeat the mean cost is (\pm SD) 35 ± 3 . The presented scenarios are: 1) Producer with boss, 2) Producer without boss, 3) Middleman who sold to a wholesaler outside of the communities 4) Local wholesaler who sold to a retailer in Belém, 5) Wholesalers outside of the communities who sold to the retailer in Belém and 6) Retailer who sold to the consumer.

1) Producer with boss

The average monthly production of the producers varied between 96 and 126 kg of the pulp crabmeat and 29 to 38 kg of the *chela*e crabmeat. The crab fishermen worked an average (\pm SD) of 4 ± 1 days per week. The average monthly sales price varied between R\$ 3.50 and R\$ 6.00 for pulp crabmeat and, R\$ 5.00 to R\$ 7.00 for *chela*e crabmeat. The total production cost involved was R\$ 1.85 per day, and remained constant throughout the year 2003.

Cost (C) =	R\$ 0.10 cotton thread to fix gloves
	R\$ 1.00 tobacco
	R\$ 0.15 match box
	R\$ 0.10 tobacco paper
	R\$ 0.50 basket
	<hr/>
Total cost	R\$ 1.85

Considering the accrued costs per month, the net income of a producer with a boss was a minimum of R\$ 470.00 and a maximum of R\$ 778.00, in June and December, respectively (Appendix 14).

2) Producer without boss

The average monthly production of the producers varied between 96 and 126 kg of the pulp crabmeat and 29 to 38 kg of the *chela* crabmeat. The crab fishermen worked an average (\pm SD) of 4 ± 1 days per week. The average monthly sales price varied between R\$ 3.80 and R\$ 6.00 for pulp crabmeat and from R\$ 5.40 to R\$ 7.30 for *chela* crabmeat. The total production cost involved was R\$ 5.85 per day, and remained constant throughout the year 2003.

Cost (C) =	R\$ 0.10 cotton thread to fix gloves	}	Production costs
	R\$ 1.00 tobacco		
	R\$ 0.15 match box		
	R\$ 0.10 tobacco paper		
	R\$ 0.50 basket		
	R\$ 1.00 boat ticket		
	R\$ 3.00 wood and salt	}	Processing costs
	R\$ 0.50 plastic bag		
<hr/>			
Total cost	R\$ 5.85		

Considering the accrued costs per month, the net income of a producer without a boss was a minimum of R\$ 512.00 and a maximum of R\$ 723.00, in March and July, respectively (Appendix 15).

3) Middleman who sold to wholesalers outside of the communities

Middlemen bought a monthly average of 380 to 1912 kg of pulp crabmeat and 76 to 426 kg of *chela* crabmeat. The crab fishermen worked an average (\pm SD) of 4

± 1 days per week. The average monthly sales price varied between R\$ 4.00 and R\$ 6.50 for pulp crabmeat and R\$ 6.00 to R\$ 7.50 for *chela* crabmeat. The costs involved for the middlemen were limited to the acquisition of the quantity of crab, the quantity of the wood and salt, and the number of people to process the meat. The costs varied between R\$ 2,098.00 and R\$ 14,568.00. The highest monthly net income generated varied between R\$ 41.00 and R\$ 1,968.00 (Appendix 16).

4) Local wholesalers selling to retailers in Belém

Wholesalers bought a monthly average of 420 to 2240 kg of the pulp crabmeat and 36 to 508 kg of the *chela* crabmeat. The crab fishermen worked an average (\pm SD) of 4 ± 1 days per week. The average monthly sales price varied between R\$ 4.50 and R\$ 7.00 for pulp crabmeat, and R\$ 6.50 to R\$ 7.80 for *chela* crabmeat. The costs involved for the wholesalers were limited to the acquisition of the quantity of crab, quantity of diesel or the boat, the quantity of the wood and salt, the number of people to process the meat, quantity of plastic bag to pack the crabmeat, quantity of ice to conserve the crabmeat and the ticket to Belém. The costs varied between R\$ 1,164.00 and R\$ 10,978.00. The highest net income generated varied between R\$ 170.00 in May and R\$ 1,994.00 in September (Appendix 17).

5) Wholesaler outside of the communities selling to retailers in Belém

Wholesalers bought a monthly average of 216 to 4048 kg of the pulp crabmeat and 56 to 1204 kg of the *chela* crabmeat. The crab fishermen worked an average (\pm SD) of 4 ± 1 days per week. The average monthly sales price varied between R\$ 6.20 and R\$ 9.00 for pulp crabmeat, and R\$ 8.20 to R\$ 11.00 for *chela* crabmeat. The costs involved for the wholesalers were limited to the acquisition of the quantity of crab, quantity of diesel or the boat, the quantity of

the wood and salt, the number of people to do the processing, quantity of plastic bag to pack the crabmeat, quantity of ice to conserve the crabmeat and the ticket to Belém. The costs varied between R\$ 1,861.00 and R\$ 22,170.00. The highest monthly net income generated varied between R\$ 355.00 in May and R\$ 4,806.00 in March (Appendix 18).

6) Retailers selling to consumers

Retailers bought a monthly average of 214 to 4048 kg of the pulp crabmeat and 55 to 1205 kg of the *chela* crabmeat. The average monthly sales price varied between R\$ 9.40 and R\$ 12.90 for pulp crabmeat, and R\$ 12.90 to R\$ 14.60 for *chela* crabmeat (Appendix 19). The highest monthly net income generated varied between R\$ 423.00 in May and R\$ 21,094.00 in February (Appendix 19).

Comparison of the average monthly net income for the six scenarios showed that retailers who commercialized in Belém had the highest net income (Figure 40). On the other hand, producers and retailers had the highest profit / kg (Figure 41)



Figure 40: Mean monthly net income of mercantile agents involved in the processed crab commercialization, Bragança District, 2003.

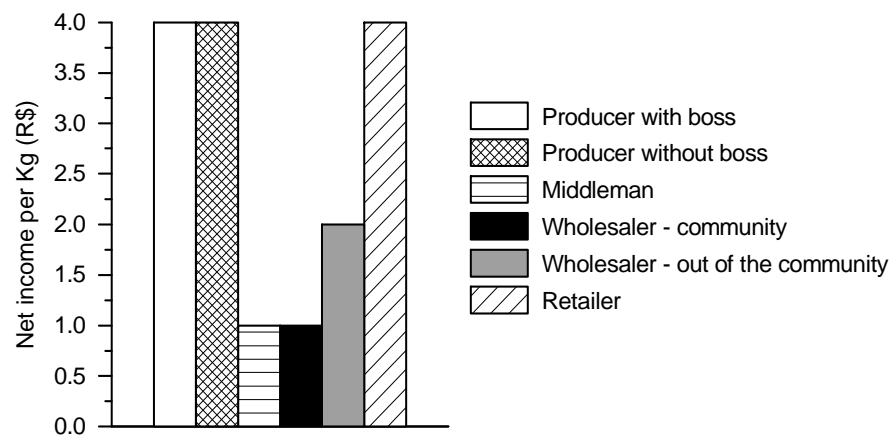


Figure 41: Mean monthly profit per kilogram of mercantile agents involved in the processed crab commercialization, Bragança District, 2003.

3.3.1.2.8 Marketing margin

In the analysis of the marketing margin of commercialization for processed pulp crabmeat, the producer marketing margin (MP) varied between 32 % (November and December) and 48% (July) (Figure 42). In the first half of the year, the best marketing margins were achieved in April and May. In the second half of the year, the producers achieved a large marketing margin only in July. The producer marketing margin (MP) plummeted in the last three months of the year (Figure 42). The marketing margin of the middleman (MC) was low and varied between 3 and 12%, in May and June respectively. The marketing margin of the wholesalers (MW) was 13% in March and 28% in June. The retailers had a marketing margin of 26% in May and 44% in November and December.

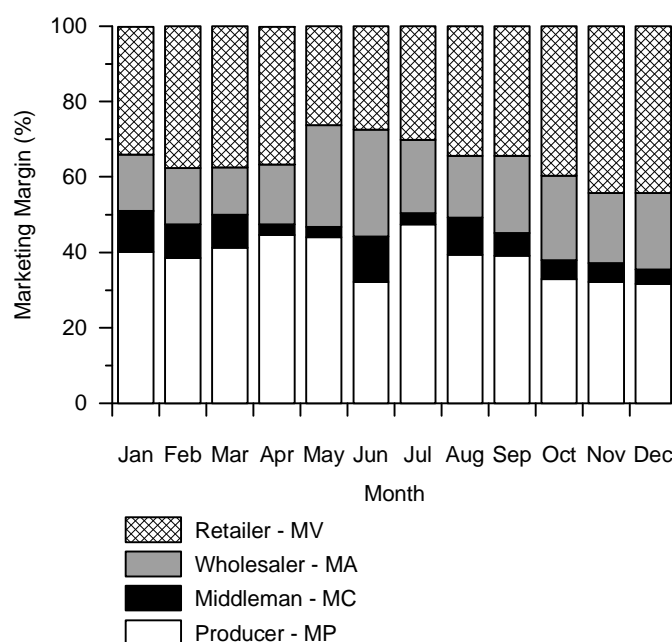


Figure 42: Relative marketing margin (%) for the mercantile agents from the commercialization of pulp crabmeat in 2003.

Analyzing the marketing margin of commercialization for processed *chela* crabmeat, the producer level showed variations between 38% and 49%, registered in December and May/July, respectively (Figure 43). The marketing margin for the middleman (MC) was low and ranged from 1% (May) to 9% (February/March). The marketing margin of the wholesaler (MW) was 11% in April and increased to 24% in June and July. The retailers had a 24% marketing margin (July), with the highest value registered in the October (42%) (Figure 43).

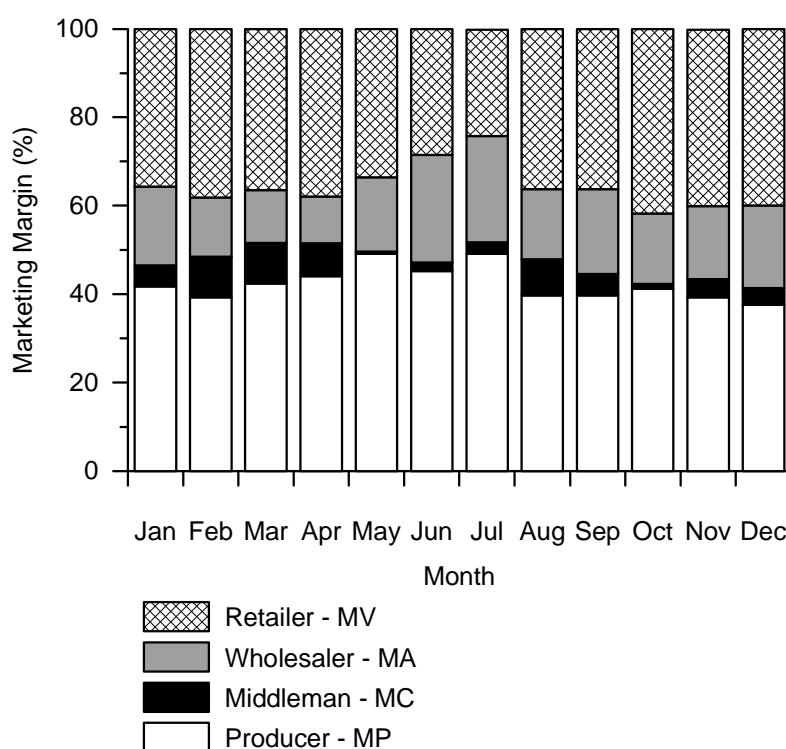


Figure 43: Relative marketing margin (%) for the mercantile agents from the commercialization of chelae crabmeat in 2003.

Figures 42 and 43 show that the marketing margin of commercialization by the crab fishermen is kept between 32 and 49% for processed crabmeat. The variation of the total marketing margin during the year of 2003 was between 51 and 68%, indicating that the commercialization chain absorbed more than 50% (half) of the price in relation to the price set by the producer.

3.3.1.2.9 Markup

The total markup (MKT) in the commercialization system of pulp and *chelae* crabmeat showed that the price paid by final consumer during the year of 2003

was always more than double the price at first commercialization (Figure 44 and Appendix 20 and 21).

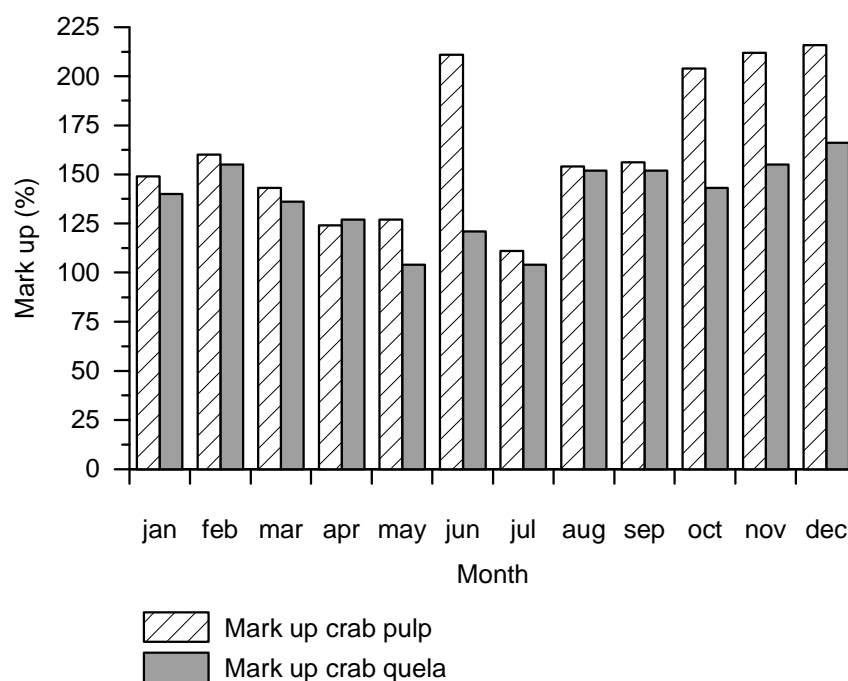


Figure 44: Percentage of total markup (MKT) during the commercialization of processed crab in 2003.

3.3.1.2.10 Target Market

The processed crabmeat from Caratateua and Treme was commercialized in Belém. From Belém it was transported to other States such as Ceara, Tocantis, Goias and Brasilia (Figura 45). This type of commercialization was possible because the retailers of Belém had licenses (stamp of federal inspection - S.I.F) to commercialize outside of Pará State. Therefore, the product could be

transported via airplane or truck. However, another form of transport used was trucks that came to Bragança City in search of fish and included crabmeat in their mixed loads.

In Tamatateua, one family produces processed crabmeat that is then brought to Mosqueiro market via route 3. (see Figure 33).

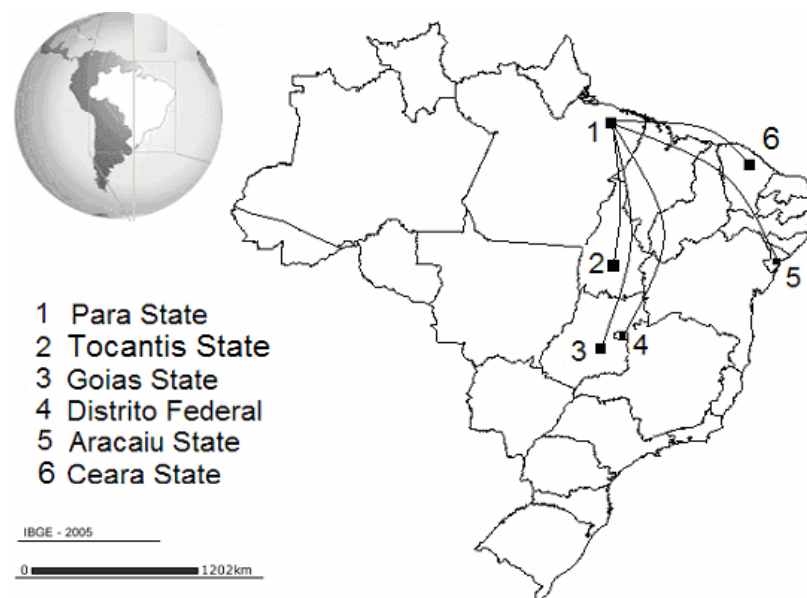


Figure 45: Route 4: transport of processed crab from Bragança District to markets of other States, 2003.

3.4 Discussion

3.4.1 Live crab commercialization system

Studies on commercialization chains of artisanal fisheries have been developed following definitions used for micro economy (Henderson *et al.*, 1971, Ferguson, 1972, Hoffman, 1987) and models of family agriculture (GTZ, 1993; Inhetvin *et al.*, 1999). The same approach was used for the present study.

The results of this study showed that 51% of the total crab landings in Bragança District were commercialized as live crabs, with the *cambada* as the predominant commercial unit. This represents 95% of the landings in Tamatateua and in Taici. The demand for live crab in the Brazilian population has a traditional character in the coastal areas. In the State of Pará, the majority of all landings were commercialized as live crab, directly by the wholesalers/retailers in the markets of the diverse districts (Silva, 2004). In the northeastern states of Brazil, direct consumption on beaches is very high and 70% of the total landings in the Piauí State were sold as live crab (Legat and Puchnick 2004).

In Taici 73% of the production was commercialized directly by the producer without a boss while in Tamatateua this was only the case in 25% of the commercializations. This implies that fishermen from Taici are much more independent in all aspects of the fishery (including commercialization) than those from Tamatateua. The easy access to the mangrove areas for the Taici crab fishermen, facilitated by the construction of the Bragança-Ajuruteua road, gives them an advantage when carrying out commercial transactions. They can reach areas close to the mangroves by bicycle or bus, capture crab, and can easily travel to the markets when they have finished. Another option open to them is selling their capture directly to wholesalers or consumers on the road. The crab is

a perishable product that must be sold immediately and the speed of transport to the market or the accessibility of the landing area to buyers is very important. The situation for crab fishermen from the Tamatateua community was different, as they are located far from the markets and the transport flow was low and unreliable. The most frequently used form of transport in this community was the school bus that generally carried students to schools, but also took other people to Bragança City. Though the frequency of the transport was four times per day during the week and two times on Saturday, this did not correspond with the tide dependent work schedule of the crab fishermen entering or exiting the mangroves. The landing ports for live crab were located far from the markets and were difficult to access (especially in the rainy season) for wholesalers/retailers and consumers, discouraging frequent visits and commercialization at the landing ports. The community's relative isolation seemed to limit their ability to commercialize independently of their boss and thereby favored crab fishermen's dependency. The phenomenon of the dependence of artisanal fishermen on mercantile agents is old and has been sufficiently commented on in scientific articles (Duchrow, 1999). These dependences are traditionally fostered by two factors: a) remote or hard to access regions where producer contact with the consumer market is not possible and an oligopolies structure in the first link of the commercialization chain develops, and b) the artisanal fishermen do not have enough cash flow to finance their own equipment, to keep up and supply a boat and/or to cover fishing-unrelated expenditures due to their families' needs (Duchrow, 1999).

The main mercantile agent identified in the live crab commercialization chain was the wholesaler/retailer, who carried out a double function. They bought large quantities from the producer (wholesaler) and resold the produce in small quantities to the consumer (retailer). As all commercialization channels initiate with the producer and terminate with the final consumer (Stern *et al.*, 1996; Mendes 1994), this chain can be considered as short and simple, due to the low

number of mercantile agents. Approximately 6,051,292 crabs passed through this single chain in 2003, representing 935 t of commercialized live crab.

All three commercialization channels identified for live crab were related to the financial situation and location of the producer who sold the crabs. A producer who captured crabs close to the road had better commercialization condition. The producers from Tamatateua were restricted to commercializing at the landing ports, where only a few wholesalers frequently went. Traditionally, the commercialization of seafood products captured with an artisanal system consists of a process that transfers the raw material (crab, fish and others) from the producer to the consumer. For a consistent analysis it is necessary to identify all activities and necessary institution involved in the transfer of the raw material, from the production to the consumption places, resulting in two flows in contrary directions: a) physical flow – product from the producer to the consumer - and b) financial flow - cash (Carvalho *et al.*, 2003). In the case of live crab the first sale occurred soon after landing, and the crabs where then relocated to the Bragança city markets, or waited for the boss to arrange transport to locations outside of Bragança District. In the latter case the crabs where transported overnight and commercialized the following morning. The present study showed that the mortality rate for the Bragança markets is normally around 2% and about 8% for the Belém markets. However, when crabs were landed in the ports between 15:00 and 17:00 h and were left until 19:00h to be transported by truck to the Belém markets, the mortality increased to between 10% and 12%. This result is still much lower than the mortality rates observed in the transport of crabs in the Piauí State. In the crabs transported from Piauí to Ceará State the mortality lay between 40 and 60% due to inadequate conditions in the transport of the animals (Legat and Puchnick., 2004; IBAMA, 2000).

Crab capture in Para State is not different from other Brazilian States, such as Bahia and Rio De Janeiro State, in that the fishery is active all year round,

providing a continuous supply of crabs (Passos and Benedito, 2005). However, the Brazilian legislation has defined a capture ban period for crab capture, aiming at the long-term preservation of the species (see chapter 4). In Bragança District the biggest peaks of production were observed in January, February and December of 2003. These results correspond with results from Glaser and Diele (2004) who found the highest captures between November and May during a five year period. The seasonality of the supply directly affected the price, primarily because the demand remained constant. In the first three months of the year the price was low as a function of the large captures in the reproduction period (*andada*). This is also common for producers in mangroves areas outside of Pará State. The crab fishermen in the northeast of Brazil consider the reproduction period as an inopportune time because the increased supply but constant level of demand decreases the value of the crabs. In this period the prices sink below half of the value that is paid in other times of the year (Nordi, 1994). The characteristic instability and dependence on climatic and biological conditions make this fishery activity not well favored by the economic sector. The reproductive cycle provokes instability in the production and in the supply, while the demand is generally steady throughout the year. As a result of this situation, the prices fluctuated to different degrees throughout the whole year (Fonteles-Filho, 1977b and 1983). The reduction of the supply observed from April to August, provoked an increase in the prices on all levels of commercialization. This period of supply reduction can be associated with the crabs' preparation for the molt which cause them to dig deeper into their burrows, making them harder to capture (Diele, 2000; Alves *et al.*, 2002). This is also the period when the fish harvest resumes and so it is possible that many crab fishermen go fishing some days per week instead. In July, the price increase stands in relation to a diminishing supply, but is also a function of an increase of the demand. At this time, school vacations start and a part of population typically relocates to the beaches where consumption of live crab is traditionally enjoyed. Though this generally pushes the prices up, differences in pricing vary greatly between

locations. For example, one *cambada* was commercialized on Salinas Beach (80 km from Bragança District) for R\$ 8.00, while the same quantity was priced at R\$ 5.00 on Ajuruteua Beach and R\$ 6.00 on the Belém market. The market price is commanded by the laws of supply and demand (Bressler *at al.*, 1970). During the proper crab harvest from September to November the prices decreased in relation to July, due to the balanced supply of the product.

For producers working in the mangrove areas next to the Bragança-Ajuruteua road, two factors influenced the monthly price variations. One was the crab supply and the other the number of wholesalers at the landing points. When there were few wholesalers at the landing points the price paid to producers diminished and better prices were only achievable if the crab fishermen went to the Bragança markets. With many wholesalers present it gave the crab fishermen a better negotiation angle. For crab fishermen with a boss it was different because the boss defined the crab price. Amongst the crab fishermen that depended on the boss the price paid was not uniform, in that different fishermen received different prices for their produce, depending on their degree of prior debt accumulated with the boss.

The period of reproduction had a strong influence on prices paid to wholesaler/retailer selling crab on the Belém Market. As the reproduction period occurs simultaneously in all Pará mangroves, this high production is drained mainly to the Belém markets, and other Districts markets. This situation caused Belém market prices to plummet, leaving them at a lower level than Bragança market prices from January to March. The Bragança market is supplied with crabs from the study area and since the high production cannot be completely absorbed by the local market the remaining portion is sold to areas outside of the Bragança District. In the other months of the year the prices on the Belém market were always higher than Bragança market prices.

The monthly average net income generated by the crab fishermen with the commercialization of live crab in *cambadas* was lower, R\$ 314.00 (with boss) and R\$ 367.00 (without boss), than the net income available to the wholesalers/retailers that resell live crab in Belém (R\$ 2,597.00), in 2003. If 20 days of work per month are considered, the daily net income for crab fishermen is R\$ 15.70 (with boss) and R\$ 18.35 (without boss). These results differ from those put forth by Glaser and Diele (2004) who analyzed the income of the crab fishermen from Furo Grande (part of the Bragança Peninsula) who received R\$ 8.80 (net income), in 2001. A possible explanation for this difference could lie in the estimations made for the production costs. In this study we only consider production costs as those products bought by the crab fishermen, as for example: cotton thread to fix the glove, tobacco, match box, tobacco paper, plastic thread to make *cambada* (atilho) and bus tickets (two ways). The shoes and gloves used by the crab fishermen were not considered because they are not bought. The proper crab fishermen or their women make the gloves from used cloth pieces and the shoes from pieces of used bicycle tires. The hooks are also not purchased as they are confectioned by the proper crab fishermen. The canoe rent is more frequent in Taici than in Tamatateua, because more crab fishermen are independent (without boss) in Taici. It is also possible that in 2001 the commercialization prices were lower than in 2003, and therefore the income of the crab fishermen was also lower for that year. Other results had shown that the monthly net income of crab fishermen was R\$ 270.00, considering individual crab sales and not *cambadas* as the commercialization unit, for crab fishermen that captures crab in the northeastern Para mangrove (Silva, 2004). These values of income cannot be easily compared with results from this study because the sales units are different. However, it is important to emphasize that many landing places are isolated, compelling the crab fishermen to keep dependency relationships with their boss, especially since the majority of the landing points is located far from the markets, making it difficult to sell crab directly to the final consumer.

Other values of net income have been estimated for crab fishermen from Piauí and São Paulo States. The monthly net income of crab fishermen from Piauí was between R\$ 80.00 and R\$ 120.00. The crab fishermen from São Paulo earned about R\$ 700.00 per month during the harvest time and R\$ 400.00, outside of the harvest time (Barbieri and Mendonça, 2004). The Piauí and São Paulo mangroves are sufficiently different from the northern region that a direct comparison with results from this study would only be possible if additional information were available. This information would have to include for example: landing points, number of mercantile agents involved in the commercialization and sales prices.

Most importantly, the independent producers (average net income R\$ 367) earned an average of R\$ 53.00 more per month than dependent producers (average net income R\$ 314), sufficiently significant for people living in poverty. In either situation the net income was higher than the minimum wage (R\$ 240.00) in 2003. However, these crab fishermen have an average of three children and their wife, and so need to support five family members with their income. When the monthly net income is divided by day, the daily income for a family of crab fishermen that commercializes live crab was between R\$ 10.50 and R\$ 12.27. According to studies carried out by the DFID (2004) the crab fishermen are among the 36 million Brazilians ($\frac{1}{4}$ of the Brazilian population) living in poverty that survive on one dollar per day per person. Other studies on artisanal fisheries confirm this situation, as Smith (1981) and Scudder and Conelly (1985) who show that though most fishermen earn above the minimum wage with \$2.00 per day during the harvest time, they are forced to turn to other occupations, such as subsistence farming or wage labor, to support themselves during the slack season when fish are difficult to catch.

The local wholesaler/retailer received a monthly average net income of R\$ 384.00. However, this agent had no production costs (except money to buy

crabs) and did not generate his income exclusively with crab sales, but had other income generating activities. These wholesalers were known as small scale buyers, were on the Bragança-Ajuruteua road, did not have boats and did not finance the producers, and bought crab at higher prices than the boss. The wholesaler/retailer that commercializes outside of the Bragança District reaches an average monthly net income of R\$ 2,597.00. However, it was not possible to estimate the depreciation costs of the truck, costs for engine part, repairs and other expenses that reduce the net income. The wholesaler/retailer who moves the production to other Districts does not need to have a specific license and does therefore not pay taxes. Control for this type of commerce does not exist; but wholesalers/retailers usually carry people and produce together in the back of the truck, which is forbidden by law.

The commercialization margins observed in the commercialization channels of live crab were different for dependent and independent producers. The marketing margins of the dependent (boss) crab fishermen were equal or below 60% and that of the independent crab fishermen were equal or higher than 60% throughout year. The remaining 40% marketing margin was divided among the wholesalers/retailers. There are two key ways to improve the marketing margin. First, by increasing the price and secondly, by decreasing the production costs for the good (Thierauf *et al.*, 1970, Helmberger *et al.*, 1977). Obviously, both are easier said than done. The crab fishermen with a boss have difficulty to increase the price because they are financially dependent. The boss loans money to the crab fishermen on a daily basis to buy food for their families before they leave to catch crab for the day. Or, the crab fishermen buy food on credit in the boss' own small shops. This holds the crab fishermen in a cycle of debt that gives them little leverage when it comes to negotiating prices for their product. The net income of those crab fishermen is insufficient to save money. In the case of independent crab fishermen, though not bound to a boss, their limitation in raising the price for their product lies in that this would involve traveling to the larger markets on their

own. For both types of fishermen, production costs could only be decreased by purchasing large quantities of the materials needed for crab capture in city centers, where the prices are lower. This would not only involved traveling to the cities but also jointly organizing their commercialization efforts. The long work hours and limited time for fishermen and the dangerous and isolating nature of the activity discourages, among other social factors, the formation of joint organizations. The marketing margins should not be confused with the net income. The marketing margin must cover the costs to transfer merchandise from one commercialization step to another and still guarantee a reasonable return for the seller (Shepherd, 1993). The final consumers in Bragança paid 45% more than the initial producer price and double the price in Belém, approximately 95%. These results showed that improved organization of the commercialization could improve the net income for the participants.

3.4.2 Processed crab commercialization system

In Bragança, 49% of all crab landings were commercialized as processed crabmeat, using the unit of kilogram. This represented 95% of the crab landing in Caratateua and Treme. Furtado (2001) and Maneschky (1995) described that the processed crabmeat commercialization initiated in the 1970's in Bragança City, and was later introduced in Carateua and Treme. In these communities approximately 55% of the processed crab was commercialized between the producer and the boss, and only 45% directly was sold directly to the consumer by the producer. In this case, although the two communities are also located distant from the commercialization market, it appears that this commercialization type (processed crabmeat) supports that the crab fishermen become independent. Processed crabmeat does not need to be sold immediately, can be conditioned on ice and sold later. Processing the crabs is typical for these communities, but in the months of lesser production (May and June), some crab

fishermen prefer to sell live crab, due to less viability when processing small amounts of crabs. According to Alves (2003), the commercialization of live crabs in Caratateua developed in the 1960's, with captured crabs bought and sold live in baskets by small wholesalers, who resold to traders outside the community. Today, the basket is still used inside of the community, but the unit of kilogram (kg) is used for commercialization outside of the community.

The number of mercantile agents involved in this system is larger than in the live crab system. The actual number of active mercantile agents depends on the product to be commercialized, product location, the organization of the producers, infrastructure and the cash flow in the chain (Tahim, 1990). The main agent identified in this commercialization chain was the middleman, who controls and guarantees the purchase of the product for the wholesalers outside of the community. They also allow the crab fishermen a full day of work by loaning money to buy food stuff for the family and organizing the boat departures to the mangrove areas. He functions like a warehouse where processed crabmeat is bought and sold. The warehouse system requires, necessarily, an organized storage and office space which is placed central enough to facilitate the commercialization transaction (Rangel, 2003). The figure of the middleman also appears on the fish markets in India, where they negotiate between the producer and the wholesaler, receiving a commission from both that corresponds to 5% of the total value of the fish commercialization (FAO, 2001b). The wholesalers are important in this commercial system because they drain the production to areas outside of the communities. In general, they were the boss of several producers and proprietor of boats that carried the producers into and out of the mangroves. They also bought the entire production from the crab fishermen, thereby defining the final price of the commercialization. Some of these wholesalers were local traders and the crab fishermen received foodstuffs to pay back later at a higher price. The retailers of this system sold processed crabmeat to the consumers. Other markets, as for example the fish market deriving of artisanal fisheries in

Asia, also involve between 3 or 4 mercantile agents. These agents operate between the producer and the final consumer with characteristic agents for each market (FAO, 2001b).

The crab producers of Bragança District are not properly organized to commercialize their crabmeat products, which facilitates the creation of middlemen networks. Diegues (1990 and 2001) also confirms that the process of commercialization for artisanal fish production is dominated by a network of middlemen that start with the individual wholesaler, generally somebody of the community who specialized in buying and selling fish, to representatives of companies who buy and finance the production. The profits from this commercialization for the producer are small and highly variable, making the accumulation of internal capital difficult. The majority of the producers had revealed their dissatisfaction with the profitability of crab capture as the main source of income. Many are unaware of the economic aspects of the activity and other related losses in its production; others stated that they knew the power of the value of the product when sold outside of Bragança District. However, crab capture in the mangroves is so tiring, that few would even consider making the trip to Bragança or Belém to sell the product on their own. In addition, the producers felt incapable of negotiating the products in the cities.

The commercialization channel identified for the processed crab was longer, involving more mercantile agents, since it is not necessary to sell the product quickly. Depending on the conditions of processing and storage of the product, the time for the commercialization can be extended. Approximately 5,970,277 crabs (= 924 t of processed crabmeat) passed through the commercialization chain for processed crabmeat in 2003. The commercialization was characterized as an oligopoly, involving few wholesalers who command the market without competition (King, 1961; Barbosa, 1985). The commercialization channel identified for processed crabmeat in Bragança District did not differ from other

places. In Cambodia, the commercialization of processed fish is carried out by local traders of small and medium scale. Under normal conditions, the fisherman (production) works on a small scale and the middlemen or wholesalers work on a medium scale (APIP, 2001).

In the communities that processed crab the reduction of the supply was between March and August. The reduction of crab supply for processing was less than that of live crab commercialization from March to July. It is possible that this reduction is associated to two factors: a) some fishermen may switch from capture crab to fishing before the end reproduction period of the crabs and/or b) period of molting (ecdise) of the crab. Maneschky (1993), in studies carried out in Pará State (Brazil), observed that when the crabs start to close the burrows to begin molting (ecdise), the captures were gradually reduced, since at this time the carapace of these animals is soft and considered improper for consumption. Also to consider is, that shortly after the exchange of the carapace they are lean and less flavorful. For this period was observed that the average size at capture decreased and the capture of females increased. This was observed mainly in the community of Caratateua. However, the biometric data collected in the Caratateua community had to be discarded. The biometric data consisted of measurements of the first left leg of the animals which can, like all the crab's legs, regenerate when it is lost and is consequently not a reliable indicator for carapace width. With smaller crabs and the capture of females (who are smaller than males), workers needed more crabs to produce one kilo of the processed product. In this case, crab fishermen preferred to sell the baskets of crab pieces to the middlemen.

In the commercialization channel of processed crab, the final sale is carried out by small stores, supermarkets and restaurants (retail). Small store owners acquired a weekly average of 400 kg of the processed crabmeat in some Districts. There was interest on the part of these retailers in contracting a group

of producers in an attempt to guarantee the regular supply of the product. However, the producers are not organized in any form of association that could handle the commercialization of the joint captures.

Pulp and chelae crabmeat achieve different pricing, with pulp crabmeat sold at much lower prices than the chelae crabmeat. The monthly average income of the crab fishermen who commercialized processed crabmeat was higher than that of the crab fishermen who commercialized live crab. In the commercialization chain of a product the stage of processing adds value to the product, diminishing the losses and increasing the income. In this case, the costs of production and processing are higher, but the addition of value through the process allows for higher pricing in the commercialization. (Castro, 1998; SEBRAE, 2002). The monthly average net income of producers that depended on a boss was R\$ 595.00 and R\$ 597.00 for those independent of a boss. The difference in the net income for these two types of producers is very small (R\$ 2.00). It was observed that in some months one earns more than the other. Since the sale prices are usually not recorded by the crab fishermen they do not perceive this difference. The great advantage of being an independent crab fisherman is that the net income acquired in the crab commercialization can be spent wherever the best prices are offered. The crab fishermen with a boss are obligated to purchase food exclusively from the store of their boss as they are paid in credit and not cash, paying a higher price. The independent crab fishermen are limited to selling to the buyers in the community with no other alternatives, diminishing their negotiation power and setting an upper limit to their income.

The middleman organizes all commercialization for the wholesaler outside of the community and puts an enormous amount of merchandise into motion. He is not contractually bound to the wholesalers, but sells the product to them after adding approximately 5% of the purchase price. The local wholesalers, who have less purchasing power than the wholesalers from outside of the community, have a

monthly average net income of R\$ 1,056.00. This net income was only earned when the wholesalers went to Belém to sell, but decreased when they sold to other wholesalers in the community. In the communities that process crabmeat, wholesalers from outside of the community were the principal financiers of crab fishing. They provided boats to carry the crab fishermen to the mangrove area and had cash to buy the capture and start commercialization. They negotiated with the retailers in Belém and also exported the production to other States. The monthly average net income for these wholesalers was R\$ 3.237,00, however many possible costs were not included in the calculation. The retailers consisted mainly of fish store and supermarket owners located in Belém. The monthly average prices in stores were 40% lower than in the supermarkets. The highest net prices/Kilo of product for commercialization in this system were received by the crab fishermen and the retailers. Again, organization of the commercialization in this system by the crab fishermen would be necessary for them to improve their income. Moreover, the techniques used to process crabs in the communities are not correct and hygienic enough to favor a long shelf life and high quality of the end product, reducing the chances for higher income for the processing workers and their family. The bad quality in artisanal fish products is a serious problem in the commercialization. Teper (1998) observed that in the commercialization of the mussel, the lack of a quality guarantee lead to a decrease in economic returns; this can be seen in artisanal groups in general, who do not observe hygienic norms and health standards in their products.

For the producers of processed crabmeat the marketing margin for the commercialization did not surpass 40%. The remaining 60% were divided among the middleman (10%), the wholesaler (25%) and retailer (25%). The margin for the wholesaler also remains constant throughout the year, and is higher than that of the retailer in May and June. The capital determines the wholesaler's ability to buy and sell more products, as well as his ability to provide for the fishermen and to keep up the boats. The wholesalers are the central mercantile individuals in

the commercialization of the crab because they finance fishing supplies and move the production to the Bragança District. The marketing margin indicates that the producer has the possibility to increase his incomes if he assumes responsibility for part of the commercialization. But it is necessary to analyze the entire situation and not only the margin as an isolated indicator. Studies reduced to margin analysis may indicate some abnormalities in the commercialization, but cannot reveal the cause. They need to be followed by studies on costs that allow the components of the margins to be determined (Freire, 1981 and Brandt 1980). The marketing margin of the producers in this work is similar to that found in the commercialization of fish, deriving from artisanal fisheries in fishing communities in the northeast of Brazil. The fish from the Barrinha and Fortaleza channel, in Ceará State, gave marketing margins of 58% to the producer (fishing), 12% to the local wholesaler, 6% to the wholesaler outside of the community and 24% to the retailer (Duchrow, 1999). Alam (2000) observed fish commercialization chains in Bangladesh and India with margins for the producer between 50 and 60% and a seasonal variation over the year.

Following the definition for markup, an incremental price increase along the chain is perceived. The wholesalers and retailers selling in Belém are the agents responsible for the main price increase from the producer to the final consumer. Wholesalers have large production costs and the retailer carries the costs of entire commercialization in Belém. Retailers pay to maintain stores (taxes, rent) which justifies a higher markup. The final consumer paid an average 164% markup for the processed pulp crabmeat and an average 138% markup for the chelae crabmeat. Product bought in the fish stores and supermarkets in Belém were more than double the price initially paid to the crab fishermen.

The Bragança District follows the national programs for fishing activities. The national politics for the development of family agriculture and fish farming officially include incentives for artisanal fisheries in Brazil though this definition is

not very clear. Fishery politics are regarded as an activity of inferior importance, though it supplies the national market with high protein food for the population. Small scale fisheries are responsible for 50% of the total captures in the world, using up only 20% of total investments in fisheries and consuming 20 to 25% less fuel than the average per ton of captured fish. They generate hundreds of times more jobs for each invested dollar than any other non-extractive activity (Panayotou, 1982). It is, therefore, an activity of high ecological economy, low public investment and high social return (FAO, 2001b).

For the Bragança economy, the volume of financial resources produced by the commercialization of crabs only in the communities was R\$ 1,872,625.00, in 2003, higher than the financial resource collected through the ICMS (R\$ 1,904,817.10) (see chapter 4). However, the Bragança District government has no control over this activity, and since the generated resources are not registered, they cannot be measured and used to justify the elaboration of incentive politics.

The fishery is a complex system, where ecological factors act interdependently and are integrated in the social and economic context. Structural alterations in this type of system are generally irreversible or, when they are reversible, this can only be achieved very slowly and at highest cost. In developing countries, the artisanal fishermen live below or close to the subsistence level and are among the poorest socioeconomic groups known. As the socioeconomic level of these families is already low, any further reduction of income would compromise their survival (Smith, 1981, Panayotou, 1980 and 1982).

Literature on commercialization of the products of artisanal fisheries and forms of social exploitation of natural resources in the Amazônia region are very scarce. This leaves no doubt to the urgency with which local abilities need to be fortified to contain the degradation process of aquatic ecosystems, so that income and

quality of life of the local populations does not suffer the consequences of neglect (Leitão, 1995 and Manesch, 1995).

CHAPTER 4 - Summary of legislation

4.1 Fishery statistics

This section presents the current and past legislation formulated for the management of the mangrove crab, *U. cordatus*, captured in Brazil. The first of these legislations appeared in the south/southeast and northeast region of Brazil. In depth studies for the northern region of Brazil had not been carried out and so the legislation for management followed that defined for the northeastern region. The creation of a national work group in 2000 (Gtcaranguejo/IBAMA), dealing with the management of the mangrove crab and new advance in research, initiated changes in the model used for the elaboration of crab legislation in Brazil. One of the first observed changes was related to the technique used to determine the carapace size of the crabs. Initially, capture size of crabs was monitored in terms of the carapace length. The new measure of carapace size considers the carapace width, more accurately reflecting the growth pattern of *U. cordatus*. Thereafter, crab legislation was specified for regions and States in consideration of the characteristics of the area. Current changes in the legislation focus on efforts to include the impact of the lunar cycle on the crab's life history.

The first specific legislation for the northern region was put forth by the Environmental Department of Pará State (SECTAM), (Law/COEMA/ n° 020 OF 26.11.2002). The period defined for banning any form of crab capture spanned five whole months (01.12.2001 the 30.04.2002) of the year, and set the minimum capture size of males at 7.2 cm (considering the carapace length). In addition, the fishing effort was restricted to allowing capture only with the arm.

The current legislation for crab fishing in the North of Brazil aims generally toward the protection of juvenal recruitment, identifying fishing areas and towards limiting the fishing effort applied.

The main management orders include:

- 1) Define capture ban period – During the reproduction period
- 2) Control the fishing effort – Formulate which fishing techniques are allowed

In 2005, the Official Environmental Department of Brazil (IBAMA) initiated and defined laws based on the research results of the MADAM Project. It considered the lunar cycle in the definition of the capture ban period which was now set for the 9th-12th, and the 25th-28th of February 2005, and for the 11th-14th, and the 26th-29th of March 2005, limiting the minimum capture size to 6.0 cm in males (carapace width).

Also in 2005, the Environmental Minister of Brazil published an emergency law forbidding the capture of *Ucides cordatus* for 10 consecutive days in the Guapimirim Area of Ambient Protection - APA. This Law was instated due to the environmental disaster caused by an oil spill in the area and aimed at protecting the public health.

The development of the crab fishing laws in all of Brazil was considered a positive aspect in the changes that were made over the last ten years. The participation of the civil society and the creation of a scientific knowledge base were instrumental for the construction of improved proposals aiming at sustainable exploitation. At present, the scheduling scheme used for the capture ban during the time of reproduction is not fully satisfactory to all decision makers. Some insist that banning capture only at full and new moons during the time of

reproduction would be sufficient to ensure adequate juvenile recruitment, though others defend a minimum three months (December-February, January-March, or December-April) banning time for that period in the crabs life cycle. The position of the MADAM Project is that a ban during the full and new moons from January to March would ensure a sustainable approach to the use of this resource. The scientific data indicate that paralyzing the crab fishery for an entire month is unnecessary and inefficient. This position is reinforced by the fact that control instruments that could enforce a capture ban are not in place and so a shorter time period would be more efficient due to higher public acceptance than a longer period without functionality.

4.2 Commercialization

The crab commercialization laws for Bragança District are based on the legislation for live or processed crab valid for all of Brazil.

4.2.1 Fish tax (or crab)

a) Live crab (*in natura*)

In Pará State, no taxes for live crab commercialization are charged. However, live crab sales to areas outside of Pará State are taxed. This tax is known in Brazil as ICMS (Tax on the relative operations of the interstate and interdistrict circulation of merchandise, rendering transport services and communication). This means that all live crab that leaves Bragança District to other districts in Pará State are not taxed. However, when the merchandise is taken to other states the ICMS must be paid. Each State of Brazil has proper legislation for the payment of ICMS. In Pará State, the ICMS is charged in the following manner: a) 4% of product value to a legal entity and b) 7% of product value to an individual. When the live crab is commercialized outside of the Pará State an additional tax is charged. It must be paid to IBAMA. This tax is charged to finance the control over the sanitary conditions under which live animal are commercialized.

b) Processed crab

Legislation for processed crabmeat is different. The product must be processed in a factory that fulfills certain standards in layout and processing procedures that are specified by law.

For the law abiding construction of a factory, several taxes must be paid at each step of the process: a) Initially, a proposal for the construction of factory must be elaborated, b) an environmental license must be requested prior to the construction of the factory c) an operations license must requested d) a certificate of health issued and e) a district license for the operation of the factory must be issued. For the attainment of these licenses taxes are charged and they must be renewed annually. In addition, the ICMS for processed crab sold to areas outside of Pará State is charged.

4.2.2 Tax and process of commercialization in Bragança

The ICMS is a state and not a district tax; and is therefore charged by the Pará State government and partly paid out to the Bragança District, following rules defined by law. The percentage of ICMS destined for Bragança District was 0.42 % of the total collected by Pará State, coming to R\$ 1,904,817.10 in 2003. This sum represented 9% of the sum total of tax collected in Bragança District (R\$ 21,237,227.55) (Table 11). The ICMS money collected by Bragança District came from diverse activities (including fishing) developed in this district. Crab commercialization to areas outside of Pará State was always officially registered as fish sales and so fish taxes were charged. How much of the total fish tax received by Bragança District actually represents crab sales is therefore unknown. The port tax and fish market tax were of low significance for Bragança District (Table 11).

Table 11: Individual and total tax money received by Bragança District in 2003

Taxes	R\$	%
ICMS	1,904,817.10	9.0
Port tax	11,764.50	0.1
Fish market	61,631.95	0.3
Others tax	19,259,014.00	90.0
Total	21,237,227.55	99.4

Through the activities of the crab fishery a substantial volume of capital is brought into district wide circulation, which is of as much significance for the communities as for Bragança City. The Bragança District must strive to elaborate and implement management models aiming at the environmental sustainability of the mangrove ecosystems, the economic sustainability of the activity and the social sustainability of the population that depends on this activity.

4.3 Creation of a conservation area

In Brazil, fisheries agreements are the most common form of participatory management for fisheries resources, and they have their proper legislation. Another type being implemented is the establishment of reserves (“*Unidades de Conservação*”, UC) created via laws enacted by the *Congresso Nacional*. The Brazilian UCs are areas with relevant features for the protection of nature, and with well-defined purpose and extension.

In the case of the mangroves of Bragança, sustainable management is an urgent necessity. The economy of the region is principally focused on exploitation of fishery resources (finfish, shellfish etc.). The region participates in the national program for coastal management (Szlafsztein, 2003), and an extractive reserve (“*reserva extrativista*”, RESEX) was recently established. RESEX is a type of UC. According to law no. 9.985 from July 18, 2000, RESEX is defined as:

Def. 18: The extractive reserve is an area used by traditional extrativist populations whose subsistence is based on extractivism, complemented by subsistence agriculture and raising of small animals, and that has as principal purpose the protection of the character of life and culture of these populations, and ascertains the sustainable use of the natural resources of the unit.

§1 The extractive reserve is under public control, with usage granted to the traditional extractive populations conforming to art. 23 of this law and underlying specific regimentations, that is, private property within its limits is to be expropriated according to what is granted by the law.

§2 The extractive reserve will be administered by a Decision Committee under presidency of the organ responsible for its administration and constituted by representatives of public organs, of organizations of the civil society and the

traditional populations resident in the area, committed to accomplish the rules and to the act of creating the unit.

§3 Visitation by the public is permitted and encouraged if compatible with local interests and in agreement with the contents of the management plan of the area.

§4 Scientific research is permitted and encouraged when conforming to previous authorization by the organ responsible for the administration of the unit, to conditions and restrictions established by the latter, and to the conventions specified in the rules.

§5 The management plan of the unit will be approved by its Decision Committee.

§6 Exploitation of mineral resources and amateur or professional hunting are forbidden.

§7 The commercial exploitation of timber resources is only admitted on a sustainable basis and in special situations complementary to the other activities developed within the extractive reserve, and in agreement with the contents of the rules and the management plan of the unit.

The mangrove area of Bragança is a RESEX and, conforming to the definition of the law, a Decision Committee under presidency of the organ responsible for its administration will be established. It will be comprised of representatives of public organs, of organizations of the civil society and the traditional populations resident in the area. It is recommended that the nominations for the Decision Committee of the Bragança RESEX include governmental organizations, non-governmental organizations and research institutions. It is important to stress the significance of the participation of research institutions because they are usually

isolated in respect to their research and do not normally participate in discussions.

In this study, some recommendations relevant for the development of a participative management plan concentrating on the sustainable exploitation of *Ucides cordatus* in Bragança District are made. No attempt was made to develop a complete work plan because more scientific and technical information would be needed, and the discussion with the community would not have been considered. However, the results of the *Ucides cordatus* fisheries statistics and the commercialization chapter have demonstrated tasks of urgent character, which have to be discussed and defined for successful development of a plan. Tasks related to environmental, social, economic and political sustainability, such as:

(Chapter 2: Fishery statistics)

Politics/environmental law

- Any administration model implemented in the area must require the revision of the fundamental Brazilian fishery laws, especially the law no. 221 of 1967. During the revision of the Federal Constitution of Brazil in 1988 this law was not updated. Updating this law will make the Brazilian fisheries legislation compatible with the conceptual advances of the last decades, principally, with the Code of Conduct for Responsible Fisheries installed by the FAO.
- Another law that needs revision is the Brazilian labor legislation that guarantees the payment of unemployment insurance for artisanal fishermen during the fisheries closed season. The law guarantees payment only when closed periods comprise a full month, meaning that the fishermen do not work for that whole time period. For *Ucides cordatus*, research results show that it is not necessary to prohibit fishing for the

entire month, but rather a four day fishing ban during the full moons and four day fishing ban during the new moons between January and March would be sufficient. However, in this case the labor legislation does not pay unemployment insurance.

These two laws (fisheries and labor) have to be discussed in any case, and they have to pass the *Congresso Nacional* (National Congress) since state governments cannot enact these laws.

Social/environmental

- With respect to the social question, problems can be solved locally. The majority of crab collectors does not have basic credentials like birth certificates and therefore, do not have other credentials that would allow them to apply for any professional or official status. In addition, the Finfish Fishery Associations (“*Colônias de pescadores*”) do not accept crab collectors as professional, artisanal fishermen. They can therefore claim neither medical assistance, nor pensions. This problem can be solved in a joint effort by the Pará State government, the District Counsel of Bragança and the Fishery Association.

(Chapter 3: Commercialization)

Economic/environmental

- The results of this study have shown that two communities are involved in product refinement of crabmeat. Prohibiting the capture of crabs during the entire reproductive season also means that many families who depend on processing crabmeat have to interrupt their activities during this period. As they are poor families they do not have the means and the capital to stock their product. They have to process and sell crabmeat every day to generate enough income for their survival. Their poverty does not allow

them to submit to any longer capture ban periods. The lack of organization in these family and small scale businesses does not end itself to quick solutions and any incentive project has to clearly accept that this is a long-term process. A second obstacle in a betterment process is related to the national law for small enterprises in Brazil. In reality, specific national laws regarding small enterprises do not exist in Brazil. The micro- or small enterprises have to follow the same legislation as large companies; therefore, small and especially communitarian enterprises are economically not viable. However, this problem can be solved at the level of the Pará State government. The state government can develop special programs for micro- and small enterprises, following the example of other Brazilian States.

- The environmental question is imbedded in all discussions and decisions. When discussing commercialization, a market size of *U. cordatus* needs to be set. When discussing legislation, relevance and value for definitions of sustainable management are sought. When the social question is discussed, the focus is put on the crab fishermen, and thereby, on their fishing effort.

Other questions related to the management must be considered, such as the local waste problem. After the crab meat is removed for processing they do not know what to do with crab carapaces and therefore dispose of everything in the neighborhood of the village. This attracts insects and smells bad. It is necessary to issue studies to find forms of usage for this waste material. Additionally, alternative income sources for the capture ban period, and/or for the period of low crab catches (molting period) have to be sought.

Chapter 5 - GENERAL CONCLUSION

The present study focused on fishery statistics and commercialization of *U.cordatus* in Bragança District and provides new knowledge to subsidize the crab fishery management in Bragança, Pará and Brazil in general. The mangrove area of the Bragança peninsula suffers the highest fishing pressure and represents an important capture area (50% of total Bragança District catch). The difference of 959 t between the catch data from this study (1859 t) and the official data of Brazil (900 t), show that the official data collection methods and collection locations used to estimate the total catch in Bragança District need to be reconsidered by the agencies responsible for the fishery statistics in Pará State. Results from this study have shown that two data collection points are especially important for crab fisheries statistics for Bragança District and should be included in any further monitoring: Furo Grande and the Caratateua community. Since crab landings from the Bragança Peninsula are very high in relation to the surrounding areas, monitoring at Furo Grande ensures that much of the catch can be recorded. The catch landed at Furo Grande is destined for the live crab market. In addition, continued monitoring at this point complements effort by the MADAM Project and thereby ensures continuity data series. In fisheries assessment, long term data series are needed to following the development of the fishery and to make to appropriate and timely decisions. The Caratateua community needs to be further monitored because from all communities close to the Bragança Peninsula, the Caratateua crab fishermen exploited the Bragança Peninsula most intensively. Crabs landed at Caratateua are destined for the processed crabmeat market.

The construction of the Bragança-Ajuruteua road contributed to the increase of fishing pressure on the Bragança peninsula. This development calls for a renewed evaluation of the state of the fishery. The growth rate ($K = 0.2/\text{year}$) for

large individuals of the species is considered low, making the species very sensitive to intense fishing exploitation. Although the average capture sizes from the Bragança Peninsula have not changed in the last five years (2000-2005) (Diele *et al.*, 2005), the data did show that the individuals captured outside of the peninsula were larger. Nevertheless, the Bragança Peninsula still presents a favorable situation for sustainable exploitation because the average size of captured individuals is sufficiently higher than the size at first sexual maturation ($L_{50\%}=3.51$ cm for male and $L_{50\%}= 4.01$ for female). Though the exploitation is presently at sustainable levels, any small fishing effort increase, deforestation or the use of unlawful capture methods can rapidly lead to overfishing of large individuals.

The crab fishery in the studied area involved about 1,195 crab fishermen who are responsible for the survival of their families. Informally, the crab capture activity generated 1,195 jobs directly and about another 1,195 indirect jobs if local people who process crab are also considered. This fishery has an extremely important function for the survival of the coastal communities and its viability cannot be simply reduced to its financial return. Studies carried out by the Department for International Development (DFID - 2004, FGV, 2002) state that an index of the income is insufficient for contemplating the multiple faces of poverty in its local context, national, urban and rural. From that perspective, the situation of the crab fishermen would not only reveal a condition of insufficient income that disables them from buying general goods, but also a complete lack of access to the essential services provided for social welfare. They are deprived of their basic rights and thereby their private rights that would ensure their access to education, to political education, health care support, acceptable housing, clean water, rubbish collection, formal work and public security. This kind of poverty translates into an obstacle for the local development of the fishing activity.

This situation is reflected in the disorganized status of the crab commercialization for part of the crab fishermen. In addition, processed crabmeat products are made under bad hygienic conditions. The necessity to develop techniques of processing and commercialization with these communities is urgent and can make a difference in the quality of life for the inhabitants. A better product on the market with a hygiene and health guarantee for the final consumer means a better income and can entice fishermen to respect the minimum capture sizes set for the crabs.

The crab fishery in Bragança District produces enough financial resources to not only allow the local families to subsist but to maintain a large money flow within the communities that is not easily apparent to the outsider. The volume of crab capture in Bragança District is large enough to supply not only the local markets, but also markets in other Districts of Pará and other states of Brazil. There is a constant flow of crab supply to Bragança, Belém and other districts throughout the year. Demand for live crab and processed crabmeat is constant.

Of the total crab landings in Bragança District only 25% are commercialized on the Bragança Market and 75% on others markets. Of the total crab volume sold on the Belém Market, 30% come from the Bragança District. The sale of live crab gives less income to the producer and more income to the wholesalers involved in the commercialization. In the commercialization of the processed crab, however, more income is received by the producer than by the other mercantile agents. The analysis of the marketing margins and the prices of commercialization had shown that an increase in the income of the crab fishermen is possible, when they take over part of the commercialization. The price analysis is an important indicator for the performance of the economy for government and stakeholders, who need to elaborate public politics, programs and projects. The data of this work show that it is possible to change the local reality of crab fishermen of the Bragança District through politics defined for the

artisanal fishing sector. It is clear that the challenge to public policies lies in changing the limiting factors to socio-economic development, as for example, basic infrastructure in the communities for education and health. In the report elaborated in 2000 for the United Nations Development Program (the UNDP) on the poverty on the planet, it was explained that, in Brazil, most of the social benefits were available only to the middle and the upper classes. The persistence of poverty is supported by the large differences in income from one social class to the next. Following the same order of reasoning, the report affirmed that new policies would be necessary to reduce inequality and to stimulate more economic growth. The local development of the crab fishery requires more functional social policies and not only programs for artisanal agribusiness to improve the product quality and to add value to the fishing production.

Although the Bragança District does not charge tax, the crab capture activity generates jobs and income for the local population. However, the process of social organization for the crab fishermen is not a short-term process. To introduce new ideas for the commercialization means to initiate routines which the crab fishermen are not accustomed to. With the enrollment of young crab fishermen the success of such efforts might be higher because they are open to change, though this can only be seen in the long run. The exclusion of profiteers from the commercialization chain does not fit the vision for local development; the idea is to empower the communities to achieve conditions allowing them to produce and commercialize as an equal in the commercialization chain. The Bragança District must elaborate structured management models aiming at the environmental sustainability of the mangrove ecosystems, the economic sustainability of the activity of the crab exploitation and the social sustainability of the population that depends on this fishery.

With the creation of the RESEX, the elaboration and implementation of the management plan will be a chance to continue with the empowerment of the civil

society that survive on the exploitation of the natural resources of the Bragança District mangroves. The function of scientists in this process is to support participative management form long term aiming at the daily survival and the future development of humanity (AGENDA 21).

The main objective of fisheries assessment is to make recommendations for the sustainable exploitation of the fish resources. All efforts made to further the knowledge of the life cycle of the species are beneficial and can always be used to advance in the direction of adequate management, necessary for economic sustainability and the preservation of biodiversity (Fonteles-Filho, 1989). To prevent errors in the management of fish resources, it is not only necessary to have knowledge of the life cycle of the involved species, but also to be aware of the commercial sector involved (businessmen, bosses and fishermen) to allow for a rational exploitation of the resource.

CHAPTER 6 – REFERENCES

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CHAPTER 7 - APPENDICES

1 – Monthly and mean total (18 months) percentile exploitation of the Bragança Peninsula and areas outside of the peninsula by Bragança District fishermen from three different communities (2003 and 2004). These values represent approximately 80% of the true fishery as not all landing points could be monitored.

	Caratateua		Tamatateua		Treme	
	Peninsula	Outside of the peninsula	Peninsula	Outside of the peninsula	Peninsula	Outside of the peninsula
	%	%	%	%	%	%
Jan	62	38	1	99	18	82
Feb	68	32	0	100	20	80
Mar	84	16	3	97	25	75
Apr	82	18	2	98	11	89
May	70	30	1	99	5	95
Jun	87	13	2	98	0	100
Jul	184	-84	4	96	9	91
Aug	67	33	0	100	11	89
Sep	75	25	1	99	4	96
Oct	82	18	2	98	25	75
Nov	77	23	1	99	12	88
Dec	68	32	2	98	11	89
Jan	77	23	2	98	21	79
Feb	87	13	1	99	33	67
Mar	84	16	3	97	18	82
Apr	74	26	3	97	4	96
May	66	34	4	96	16	84
Jun	53	47	3	97	24	76
mean	80	20	2	98	15	85

2 – Mean and standard deviation of the number of active crab fishermen recorded at four monitoring points on each day of the week during 18 months of survey (2003 and 2004).

	Caratateua Number of Crab fishermen		Taici Number of Crab fishermen		Tamatateua Number of Crab fishermen		Treme Number of Crab fishermen	
	mean	SD	mean	SD	mean	SD	mean	SD
Monday	35	20	56	27	10	14	37	37
Tuesday	64	28	81	62	34	20	41	27
Wednesday	59	32	66	25	29	18	53	30
Thursday	66	33	65	31	11	7	53	39
Friday	63	28	140	76	80	25	49	33
Saturday	32	21	115	54	82	34	48	48

3 - Bragança Peninsula – Total monthly capture, mean daily and hourly effort and CPUE recorded during 18 months of survey (2003-2004). These values represent approximately 80% of the true fishery as not all landing points could be monitored.

	Total capture Number of crabs	Effort man * day	CPUE crabs / man * day	Effort man * hour	CPUE crabs / man * hour
Jan	680540	4750	143	25584	27
Feb	682813	5465	125	29224	23
Mar	528959	4437	119	23691	22
Apr	367913	3080	119	16586	22
May	302712	2569	118	14003	22
Jun	283498	2484	114	13852	20
Jul	389082	3639	107	19219	20
Aug	396531	3044	130	16077	25
Sep	434908	2807	155	14941	29
Oct	706781	3985	177	21716	33
Nov	500615	3002	167	16059	31
Dec	557917	3432	163	19185	29
Jan	646086	4570	141	24081	27
Feb	696398	4363	160	22509	31
Mar	568725	3763	151	21259	27
Apr	438123	2914	150	16646	26
May	464924	3083	151	17449	27
Jun	363394	2643	137	14968	24
mean	500551	3557	140	19281	26

4 – Outside of the Peninsula– Total monthly capture, mean daily and hourly effort and CPUE recorded during 18 months of survey (2003-2004). These values represent approximately 80% of the true fishery as not all landing points could be monitored.

	Total capture Number of crabs	Effort man * day	CPUE crabs/ man * day	Effort man * hour	CPUE crabs / man * hour
Jan	472387	2261	209	11643	41
Feb	418541	2059	203	10708	39
Mar	226849	1384	164	7006	32
Apr	220582	1404	157	6964	32
May	179827	1224	147	6134	29
Jun	99076	788	126	4117	24
Jul	161063	1170	138	5780	28
Aug	322984	1881	172	10055	32
Sep	475860	2325	205	12453	38
Oct	485463	2160	225	11444	42
Nov	431509	1864	231	10002	43
Dec	507236	2071	245	11343	45
Jan	333738	1686	198	8881	38
Feb	552518	2742	202	14335	39
Mar	359409	1763	204	9138	39
Apr	320154	1623	197	8689	37
May	315563	1553	203	8506	37
Jun	232264	1367	170	7225	32
mean	339723	1740	189	9135	36

5 – Bragança Peninsula– The measured minimum, maximum, and mean monthly carapace width (cm) of *U. Cordatus* males sampled from the catch during 16 months of survey (2003 and 2004).

Year	Month	Number of crabs measured	Min Carapace Width (cm)	Max Carapace Width (cm)	Mean Carapace Width (cm)	Standard Deviation
2003	Mar	728	5.1	8.9	7.1	0.5
	Apr	670	5.2	8.3	7.0	0.5
	Mai	721	5.2	9.3	7.1	0.5
	Jun	222	5.4	8.4	6.9	0.5
	Jul	112	5.8	8.0	7.0	0.5
	Aug	56	5.6	8.2	7.1	0.5
	Sep	224	5.5	8.0	6.9	0.5
	Oct	112	5.8	8.0	7.0	0.5
	Nov	280	5.9	9.7	7.5	0.7
	Dec	111	5.9	8.0	7.1	0.5
2004	Jan	111	6.0	8.0	7.1	0.5
	Feb	222	5.8	8.3	6.9	0.5
	Mar	154	6	8.5	7.3	0.6
	Apr	166	5.8	8.6	7.2	0.7
	Mai	110	5.6	8.5	7.1	0.6
	Jun	392	5.9	8.5	7.5	0.6

6 – Outside of the Peninsula– The measured minimum, maximum, and mean monthly carapace width of *U. Cordatus* males sampled from the catch during 16 months of survey (2003 and 2004).

Year	Month	Number of crabs measured	Min Carapace Width (cm)	Max Carapace Width (cm)	Mean Carapace Width (cm)	Standard Deviation
2003	Mar	1063	5.4	8.8	7.2	0.5
	Apr	672	5.9	8.9	7.3	0.5
	May	1282	5.3	8.9	7.2	0.6
	Jun	1495	5.3	8.6	7.2	0.6
	Jul	559	6.0	8.8	7.3	0.5
	Aug	839	5.6	8.5	7.1	0.5
	Sep	672	5.9	8.6	7.3	0.6
	Oct	783	6.0	8.8	7.3	0.6
	Nov	448	6.0	8.9	7.4	0.6
	Dec	560	5.8	8.9	7.4	0.6
2004	Jan	784	5.9	8.9	7.4	0.6
	Feb	448	6.0	8.5	7.4	0.6
	Mar	558	5.1	8.6	7.3	0.6
	Apr	448	5.6	8.8	7.4	0.6
	May	447	5.8	9.0	7.4	0.6
	Jun	448	6.0	8.7	7.4	0.5

7 – Virtual population analysis (VPA) according to Jones (1974) for *U.cordatus* males from the study area during 12 months of sampling (March 2003- February 2004)

Size class median (cm)	Catch (tons)	Exploitation Rate F/Z	Fishing mortality F	Total mortality Z
5.1	0	0.00	0.00	0.40
5.4	3	0.00	0.00	0.40
5.7	16	0.00	0.00	0.40
6.0	232	0.01	0.00	0.40
6.3	581	0.02	0.01	0.41
6.6	820	0.03	0.01	0.41
6.9	1538	0.07	0.03	0.43
7.2	2215	0.12	0.05	0.45
7.5	2666	0.18	0.09	0.49
7.8	1805	0.19	0.09	0.49
8.1	1114	0.26	0.14	0.54
8.4	313	0.50	0.40	0.80

8 – Recorded costs (R\$) for products or services used by mercantile agents in the commercialization chain of the mangrove crab in January of 2003

Product or Service	Cost to Producer (R\$)	Cost to Local Purchaser (R\$)	Cost to Wholesaler (R\$)	Cost to Retailer (R\$)
<u>Variable Cost</u>				
In Caratateua and Treme				
Basket	0.50			
Car ticket			10.00	
Cotton Thread	0.10			
Employee				240.00
Hook	0.00			
Match Box	0.15	0.15		
Driver			20.00	
Net	20.00	20.00	20.00	
Plastic Bag - B	0.30	0.30		
Plastic Bag - S			2.00	
Tax				150.00
Tobacco	1.00			
Tobacco Paper	0.10			
In Tamatateua and Taici				
Cotton Thread	0.10			
Hook	0.00			
Match Box	0.15	0.15		
Plastic Thread - Atilho	1.00	1.00	1.00	
Tobacco	1.00			
Tobacco Paper	0.10			
Rent Car			300.00	
<u>Fixed Cost</u>				
In Caratateua and Treme				
Boat			12,000.00	
Canoe		400.00	400.00	
Freezer				
Loja				15,000.00
In Tamatateua and Taici				
Bicycle	180.00			
Boat			12,000.00	
Canoe			400.00	
Freezer				
Loja				15,000.00

9 – Mean monthly and yearly net and gross income (R\$) of a live crab producer with a boss in 2003.

Month	Gross Income (R\$)	Cost (R\$)	Net Income (R\$)
Jan	354	21.6	332
Feb	299	21.6	278
Mar	334	21.6	313
Apr	370	21.6	348
May	336	21.6	314
Jun	282	21.6	260
Jul	320	21.6	298
Aug	317	21.6	295
Sep	354	21.6	332
Oct	360	21.6	338
Nov	314	21.6	292
Dec	384	21.6	362
mean	335	21.6	314

10 — Mean monthly and yearly net and gross income (R\$) of a live crab producer without a boss in 2003.

Month	Gross Income (R\$)	Cost (R\$)	Net Income (R\$)
Jan	458	45.6	412
Feb	370	45.6	324
Mar	440	45.6	394
Apr	458	45.6	412
May	416	45.6	370
Jun	320	45.6	274
Jul	384	45.6	338
Aug	370	45.6	324
Sep	416	45.6	370
Oct	432	45.6	386
Nov	403	45.6	358
Dec	480	45.6	434
mean	412	45.6	367

11 – Mean monthly and yearly net and gross income (R\$) of a live crab wholesaler/retailer commercializing on the Bragança Market in 2003.

Month	Gross Income (R\$)	Cost (R\$)	Net Income (R\$)
Jan	1248	915	333
Feb	1075	706	370
Mar	1214	920	294
Apr	1398	957	442
May	1400	1040	360
Jun	1344	960	384
Jul	1509	1104	405
Aug	1578	974	603
Sep	1248	832	416
Oct	912	547	365
Nov	960	576	384
Dec	896	640	256
mean	1232	848	384

12 – Mean monthly and yearly net and gross income (R\$) of a live crab wholesaler/retailer commercializing on the Belém Market in 2003.

Month	Gross Income (R\$)	Cost (R\$)	Net Income (R\$)
Jan	9072	8418	654
Feb	10931	9560	1371
Mar	10608	9644	964
Apr	12169	9152	3017
May	9184	8419	765
Jun	12994	10663	2331
Jul	11400	8611	2789
Aug	13104	8148	4956
Sep	9176	7933	1243
Oct	12954	8988	3966
Nov	10586	7389	3197
Dec	14976	9059	5917
mean	11430	8832	2597

13 – Total markup (%) during processed crabmeat commercialization on the Bragança and Belém markets in 2003.

	Bragança Total Markup MKT (%)	Belém Total Markup MKT (%)
Jan	36	65
Feb	52	65
Mar	32	58
Apr	46	95
May	35	67
Jun	40	68
Jul	33	100
Aug	62	150
Sep	50	88
Oct	67	113
Nov	67	129
Dec	40	144

14 – Mean monthly and yearly net and gross income (R\$) of a processed crabmeat producer with a boss, in 2003.

Month	Gross Income (R\$)	Cost (R\$)	Net Income (R\$)
Jan	629	29.6	599
Feb	548	29.6	518
Mar	499	29.6	470
Apr	616	29.6	586
May	649	29.6	620
Jun	686	29.6	657
Jul	807	29.6	778
Aug	619	29.6	589
Sep	581	29.6	551
Oct	573	29.6	544
Nov	603	29.6	573
Dec	620	29.6	591
mean	619	29.6	590

15 – Mean monthly and yearly net and gross income (R\$) of a processed crabmeat producer without a boss, in 2003.

Month	Chelae Price	Gross Income (R\$)	Cost (R\$)	Net Income (R\$)
Jan	5.7	781	93.6	687
Feb	5.5	661	93.6	567
Mar	5.7	606	93.6	512
Apr	6.0	628	93.6	534
May	6.3	655	93.6	561
Jun	6.5	696	93.6	603
Jul	7.3	816	93.6	723
Aug	6.1	747	93.6	654
Sep	6.1	675	93.6	581
Oct	5.9	660	93.6	567
Nov	5.9	675	93.6	582
Dec	5.4	657	93.6	563
mean	6.0	688	93.6	594

16 – Mean monthly and yearly net and gross income (R\$) of a local retailer commercializing processed crabmeat in 2003.

Month	Chelae Price	Gross Income (R\$)	Cost (R\$)	Net Income (R\$)
Jan	6.0	2681	2098	583
Feb	6.5	5782	4463	1318
Mar	6.5	5824	4588	1237
Apr	6.8	2341	2206	135
May	6.8	2417	2376	41
Jun	6.8	3034	2956	78
Jul	7.5	15623	14568	1055
Aug	7.0	8546	6578	1968
Sep	6.5	3836	3198	638
Oct	6.1	8843	7446	1397
Nov	6.3	7270	6244	1026
Dec	6.0	6030	5409	621
mean	6.6	6019	5177	841

17 – Mean monthly and yearly net and gross income (R\$) of a local wholesaler commercializing processed crabmeat on the Belém market, in 2003.

Month	Gross Income (R\$)	Cost (R\$)	Net Income (R\$)
Jan	6784	5060	1724
Feb	4286	3328	958
Mar	15153	10978	4175
Apr	2686	2408	278
May	2786	2616	170
Jun	1481	1164	317
Jul	8964	7856	1108
Aug	4427	3258	1169
Sep	8210	6216	1994
Oct	6178	5074	1104
Nov	7116	5752	1364
Dec	5236	4250	986
mean	6109	4830	1279

18 – Mean monthly and yearly net and gross income (R\$) of a wholesaler from outside of the community commercializing processed crabmeat on the Belém market, in 2003.

Month	Gross Income (R\$)	Cost (R\$)	Net Income (R\$)
Jan	12886	10304	2582
Feb	35496	27768	7727
Mar	26976	22170	4806
Apr	6764	5595	1169
May	2216	1861	355
Jun	4896	3448	1448
Jul	16408	12220	4188
Aug	9114	7352	1762
Sep	14817	10730	4087
Oct	12544	8626	3918
Nov	13672	9802	3869
Dec	10848	7552	3296
mean	13886	10619	3267

19 – Mean monthly and yearly net and gross income (R\$) of a retailer commercializing processed crabmeat in Belém, in 2003.

Month	Gross Income (R\$)	Cost (R\$)	Net Income (R\$)
Jan	19654	13301	6353
Feb	57016	35922	21094
Mar	43025	27415	15610
Apr	10703	7179	3524
May	3041	2617	423
Jun	6754	5307	1446
Jul	23128	16847	6281
Aug	13994	9552	4443
Sep	22722	15247	7476
Oct	20903	12961	7942
Nov	24123	14093	10030
Dec	19071	11257	7814
mean	22011	14308	7703

20 – Total and individual markup (%) in the pulp crabmeat commercialization chain on the Bragança and Belém markets in 2003.

	Total Markup MKT (%)	Middleman markup MKM (%)	Wholesaler Markup MKA (%)	Retailer Markup MKV (%)
Jan	149	27	29	52
Feb	160	23	31	60
Mar	143	21	25	60
Apr	124	7	33	58
May	127	6	58	35
Jun	211	37	64	38
Jul	110	6	38	43
Aug	154	25	33	52
Sep	156	15	45	52
Oct	204	15	59	66
Nov	212	16	50	79
Dec	216	12	57	79

21 - Total and individual markup (%) in the chelae crabmeat commercialization chain on the Bragança and Belém markets in 2003.

	Total Markup MKT (%)	Middleman markup MKM (%)	Wholesaler Markup MKA (%)	Retailer Markup MKV (%)
Jan	140	12	38	55
Feb	155	24	28	61
Mar	136	22	23	57
Apr	127	17	21	61
May	104	1	34	50
Jun	121	4	51	40
Jul	103	5	47	32
Aug	152	21	33	57
Sep	152	12	43	57
Oct	143	3	38	71
Nov	155	11	38	67
Dec	166	10	45	67